iLRN 2017 Coimbra

Workshop, Long and Short Paper, and Poster Proceedings from the Third Immersive Learning Research Network Conference

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Table of Contents

Main Conference

Main Conference Preface ……………………………………………………… 1

Keynote and Featured Speakers

Curtis Bonk, Indiana University, USA ……………………….……. 3
Minjuan Wang, Shanghai International Studies University, China, San Diego State University, USA ……………………….…. 5
Alan Miller, University of St Andrews, Scotland and the Smart History company ……………….……………….…………………. 7
Nelson Vilhena, Critical Software …………………………………. 9
Carsten Ulrich, German Research Center for Artificial Intelligence (DFKI), Germany ………………………………….………………. 14
Jonathon Richter, Immersive Learning Research Network & Salish Kootenai College, USA ……………………………….…. 15

Long Papers

Fieldscapes – Creating & Evaluating a 3D Virtual Fieldtrip System.. 18
Enhancing foreign language learning in 3D immersive worlds – a study report ……………………………………………………….. 30
Assessment for Learning and Gamification - Can Two Walk Together, Except They be Agreed? ………………………………… 42
GAMES & GAMIFICATION IN THE PEDAGOGY DEGREE: an alternative to Distance Education models ………..……………... 54
Effects of natural user interfaces on user experience, activation and task performance in immersive virtual learning environments … 68
Improving Reading Literacy with an Immersive Learning App ……. 80
Screenwriting framework for an interactive Virtual Reality Film ….. 92

Short Papers

Using Multiplayer Digital Games to Support Collaboration in Health Education …………………………………………………. 103
Enhancing strategies for cultural and natural heritage through the ALForLab Geographical Information System …………. 109
Applying Mobile EEG to Measure Attention and Reading Time for Picture Books ……………………………………………. 121
Cultural Heritage Reconstruction Based on Virtual Reality Technology: A Pilot Study of Taiwanese Historical Site …………… 129
How to gamify classroom? A proposal for training Teachers ………. 136
Integrating Wearable Technologies and Sport Analytics for Personalized Immersive Training and Learning ………………… 144
Immersive Learning of Biomolecules ………………………….…… 156
Adopting Game Technology for Heritage Information Modelling ……………………………………………………………. 162
A Digital Museum Infrastructure for Preserving Community Collections from Climate Change ……………..……. 170

Workshop

Imagine 2017 ……………………………………………………… 179
Gamification and Mixed Reality ………………………………….. 180
Augmented Reality Trends in Education ……………………….… 181

DOI: https://doi.org/10.3217/978-3-85125-530-0-01

Posters
Proposed Model security best practices using Immersive Virtual Reality in Social Engineering …………………………………… 183
Transmedia Story-weaving: Designing immersive transmedia experiences for higher education ………………………………..… 186
V-Label : an experiment on how Augmented Reality impacts memorization …………………………………………………..… 189
Immersion strategies in nonfiction digital narratives: A Short History of the Highrise, a case study ……………………………… 204
The use of a Cyber Campus to Support Teaching and Collaboration: An Observation Approach ……………………….………………… 193

Special Tracks
Special Tracks Preface ……………………………………………..… 195

ST: Personalisation in Immersive and Game-Based Learning Environments
Analysing and adapting communication scenarios in virtual learning environments for one-to-one communication skills training ……………………………………………………….…. 197
Interaction of Learning Management Systems and Gaming Platforms in the Context of Competence Based Learning …………. 205

ST: Digital Heritage and the Immersive City
Phygital Heritage: an Approach for Heritage Communication ………………………………………………….…. 220
Once upon a time in Pergamon: Reality and Representation in the Hellenistic City……………………………………………….. 230

ST: Immersive and Engaging Educational Experiences
Towards a Transmedia Learning Approach in ESL context ……..…. 240
Travel through the oceans: augmented reality to enhance learning in early childhood education ………………………………. 248

ST: Wearable Technology Enhanced Learning
The use of sensors in virtual worlds for obesity control ……………. 257
Relaxation Simulator with Biofeedback: Discussion of Wearability…………………………………………………….….. 270

ST: Serious Games using Immersive and Assistive Technologies
Training teachers to employ a digital art history curriculum: An evaluation of the Crystal Bridges mixed distributed and virtual reality professional development……………………..……………… 283
360-degree interactive video application for Cultural Heritage Education ……………………………………………….. 297
Evaluating the Lifelog: Assessment of Recall using Galvanic Skin Response………..………………………………..…... 305
Drinking Games: Simulating Alcoholic Behaviour Patterns in the "Pubcrawler" Video Game ……………………...…… 317

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Main Conference Preface

ILRN 2017 is the third annual international conference of the Immersive Learning Network. It follows on from the inaugural conference held in Prague in July 2015 and the second conference held in Santa Barbara in June 2016.

There have been ninety-three submissions to the conference in 2017 encompassing long and short papers, posters, special tracks and workshops. This has more than doubled since last year when the total was forty-five. This research area is clearly attracting more attention as the usability and affordability of powerful virtual reality devices grows alongside the search for new modes of learning and delivering effective educational experiences. In addition to the ongoing development of virtual laboratories, bespoke learning systems and collaborative training environments the emerging interdisciplinary fields of cultural heritage, VR-related cognitive studies and VR-mediated communication are also represented in these proceedings.

The Immersive Learning Research Network is highly inclusive, keen to accommodate and encourage all interested parties to actively participate in this vibrant research area, especially by attending the annual conference. All papers and posters were independently reviewed: long papers by 3 – 5 reviewers, short papers by 2 – 4 reviewers and posters by 2 reviewers. This ensured that all authors were given a good mix of feedback on how to improve their submissions for publication and presentation at the conference. In cases where the reviewers agreed that much more work was needed for a particular format long papers were invited to be resubmitted as short papers and short papers as posters. Submissions for the main track of the conference included nine posters and thirty-four papers. Eleven of these papers were accepted for inclusion in an edition of Springer's long running series Communications in Computer and Information Sciences with the remaining revised papers and abstracts for posters being included in this volume. This publication is Open Access with a DOI and also a separate DOI for each long paper.

The main conference includes six distinguished plenaries demonstrating both breadth and depth in the ILRN. Curtis Bonk locates immersive technologies in a historical context, where the fourth industrial revolution meets the 4^{th} E-Learning revolution; Alan Miller takes time out from his busy schedule of installations from Iceland to the Caribbean to share his experiences of supporting cultural heritage and digital tourism through virtual time travel, virtual museums and community engagement; ILRN's own executive director, Jonathan Richter, highlights the pressing need to build research capacity in the area and proposes a design for an open networked global community effort; Carsten Ullrich presents results and insights from the APPist research project which investigated how adaptive technology can support the employee in the challenging environment of the shop floor; Nelson Vilhena illustrates the role of immersive technologies in computer-mediated reality giving examples from diverse contexts including mission planning, healthcare, and hydroelectric power management; Minjuan Wang focuses on augmented reality as a key emerging trend in education, providing an overview of its current development, exploring examples of curriculum integration, and describing which approaches are likely to be successful.

If you are not already involved in thinking about or using immersive learning in educational contexts we believe that these proceedings will stimulate you to so by joining the ILRN.

Colin Allison
ILRN 2017 Program Chair

Keynote and Featured Speakers

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The Fourth Industrial Revolution Meets the Fourth E-Learning Revolution

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Over the past few centuries, humankind has entered and exited a series of industrial ages from the age of steam and water power to the immense benefits of electricity and efficient assembly line workers to the tremendous life enhancements from computers and pervasive automation. Now we are on the cusp of the fourth industrial age related to cyber physical systems with extensive physical, biological, digital, and educational implications. It is in this age that we now are witnessing hyper-accelerating advancements in robotics, mobile supercomputing, artificial intelligence, drone technology, autonomous vehicles, and much more. Similarly, in education, after just two decades of Web-based learning, we have entered the fourth phase or wave of e-learning. Interesting, each of the four waves of e-learning have come exactly seven years apart.

First was the establishment of Web browsers and learning portals, brought about by Web search companies like Netscape which was founded on April 4, 1994. Seven years to the day later, MIT announced the OpenCourseWare (OCW) movement on April 4, 2001 and the age of open education was spawned. Another seven year span resulted in the first massive open online courses (MOOCs) in 2008. Now we enter the fourth phase of e-learning involving the personalization of e-learning. This is the age where experts and peers from around the globe are available for consulting and advice as well as collaboration and project-based forms of learning.

As with the fourth wave of the industrial revolution, there is immense change around the world today related to new forms of learning typically involving technology in the fourth phase of e-learning. In fact, there are three megatrends related to learning technology today: (1) technologies for engagement; (2) technologies for pervasive access; and (3) technologies for the personalization and customization of learning. To better understand these new forms of learning delivery, Professor Bonk will discuss these three megatrends as well as his recent research on the personalization of e-learning. Along the way, insights will be offered into where the fourth industrial revolution bumps into and fuels the fourth e-learning revolution.

Without a doubt, human learning is changing in dozens of ways. There has been no moment in the evolution of the human species wherein learning delivery mechanisms, learning contents, and learning requirements to survive were changing so rapidly. What is clear is that as we head toward the Year 2020, we humans are in the midst of a learning revolution. During the past few years, learning has become increasingly collaborative, global, mobile, modifiable, open, online, blended, massive, visually-based, hands-on, ubiquitous, instantaneous, and personal. And this is just a start!

This is the age of Education (and E-Learning) 4.0 where learning is more informal, resource rich, and self-directed and where learner creation of products is the new norm, often with the use of digital media. Fortunately, we are living in an age of educational resource abundance where passion, play, purpose, and freedom to learn take precedence over the more mind-numbing traditional information reception models of

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learning. The instructors and experts whom we meet and interact with along the way are most effective as curators, counselors, consultants, concierges, and cultivators of our learning. And now such mentors, tutors, experts, colleagues, and instructors can appear instantaneously on a mobile device.

Naturally, such new roles require a unique and evolving set of guiding principles. David Merrill had his famous “First Principles” of instruction (e.g., the Principle of Activation, the Principle of Demonstration, the Principle of Application, the Principle of Integration, and the Principle of task/Problem-Centered). Dr. Bonk has his “Learning Activation System Template” or “LAST” principles. Accordingly, in this talk, Professor Bonk will detail a set of 20 “last” principles of instruction including the Principle of Flexibility, the Principle of Meaningful Learning, the Principle of Choice and Options, the Principle of Cheerfulness and Optimism, the Principle of Spontaneity, the Principle of High Expectations, the Principle of Nontraditional Learning, etc. Suffice to say, there is immense change around the world today related to new forms of learning typically involving technology.

Learning is more problem-based, inquiry-driven, self-directed, and immersive. It is also increasingly digitally rich, touch-sensored, flipped, synchronous, immediate, on-demand, competency-based, game-like, communal, and so much more. In such transformational times, the role of the instructor or teacher is no longer as firmly cemented in the direct instructional and authoritarian past. Today, savvy instructors are at times a coach and cultivator of talents, and, at other times, a concierge, orchestra conductor, or curator finding the golden nuggets from the open educational world and offering learners a diverse and exciting array of learning paths and opportunities. Still other times, the instructor offers timely scaffolds and sage guidance as an on-demand consultant or counselor. There is also the increasingly vital role of course ambassador who excites the world into an emerging idea, event, or concept, or perhaps an entire course, program, or discipline through a massive open online course or “MOOC.”

This talk will attempt to sort through many of these trends and transformations in learning as a means to push our thinking about what the near and far future holds for us humans in terms of where we learn, what we learn, and who we will be learning with. Such exciting times call for exciting talks.

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Augmented Reality and Education: Design, Implementation, and Impact

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Augmented reality (AR) is technology which overlays virtual objects (augmented components) into the real world. These virtual objects then appear to coexist in the same space as objects in the real world. Augmented Reality (AR) affords the ability to overlay images, text, video and audio onto existing structures, space or imagery in real time and in context with learner's environment. The engaging nature of AR make it an especially attractive tool for education. AR normally is used in real time and in context with environmental elements. By incorporating virtual and real world experiences AR has many potential applications in education and product development (Greenwood & Wang, In Press).

There are currently three main types of AR technologies: 1) Head-mounted displays and wearables (see Figure 1), 2) Mobile handheld devices, and 3) Pinch Gloves. "Head-Mounted Displays are complex technological devices that allow a learner to see computer- generated images overlaid onto the real world via a digitally enhanced viewfinder" (Novak, Wang, Callaghan, & Zhao, 2012, p. 96). The second category, mobile devices, are prevalent and can be easily integrated into learning settings. Indeed, most of the AR applications used in education today rely on mobile Apps and devices such as Aris and Aurasma.

AR has been considered a significant tool in education for many years (Gredvig, Larson, Ridolfi, & Romenesko, 2011). The world has also witnessed exemplary uses of AR in education, from K-12 to higher-education, from formal learning to informal learning. Immersive and Social learning theories provide the foundations underlying the use of Augmented Reality and mobile AR in teaching and learning (Greenwood and Wang, In Press).

As Greenwood and Wang (In press) argued in their book chapter, in education, it seems that AR's development has followed a similar trajectory to mobile learning, which was heralded as mainstreaming education but eventually became a supplementary educational tool in most countries. However, from learner perspective, mobile learning is already part of their daily lives. Learners do not draw a clear line between how they learn, either online or mobile. They tap into all devices available and networks available to learn at work, at home, on the go, or in a face-to-face classroom (Greenwood and Wang, In press). Therefore, convenience, flexibility, and mobility associated with AR-infused activities have greatly appealed to the mobile generation.

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Figure. 1 SDSU Graduate Student (Nader Elnaka) trying out Oculus Rift, filmed by his teammate--Kevin Storm Jorgensen.

As the usage of mobile devices in formal settings continues to rise, so does the opportunity to harness the power of augmented reality (AR) to enhance teaching and learning. Many educators have experimented with AR, but has it proven to improve what students grasp and retain? Is AR just another fun way to engage students, with little transformation of learning? This invited speaking will introduce augmented reality as an emerging trend in education, provide an overview of its current development, and also explore examples of AR implementation in both higher-education and industry. In particular, this presentation will showcase AR-related projects completed by graduate students at the Learning Design and Technology program of San Diego State University.

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Immersive installations for virtual time travel, virtual museums and community engagement

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Virtual Museums can be defined as an entity that augments or enhances a visitor's experience in a museum, act independently of the physical barriers of a museum or serve as its digital footprint; bringing together media types such as photos, videos and audio as well as 3D reconstructed environments, digital objects and virtual reality.

However, a virtual museum must maintain and encompass the definition of a physical museums set by the International Council of Museums (ICOM). This definition includes its ability for public access, an organisation of knowledge transmitted in a coherent manner, and a commitment to preservation of a collection.

That's a great definition, but also, incredibly broad.

While it acknowledges all the amazing things digital technologies can do for collections as well as for the visitor experience, suggests a virtual museum could be anything from a museum mobile app that has tours and collection information to a full virtual museum environment.

It also doesn't give much detail on the museum's ability to use this as anything but public facing. A museum is not just what the public can see when they step inside, but the constant day to day of collections management, exhibition and events planning.

When the term virtual museum was coined over 15 years ago and institutions began to invest in the idea, the types of media presented ranged from online collection database systems to complete digital environments such as those used in Second Life.

While the technology was there to use and experiment with, commodity hardware had a difficult time keeping up, limiting its use. The overall presentation was clunky and gimmicky, and the amount of detail available didn't necessarily enhance a visitor's experience, however it did give them something to do. Which isn't the best reason to invest in something.

Speed up to present day, what is a virtual museum now? Google has been doing an incredible job digitising museums around the world with its Google Arts & Culture initiative, using its Street View software to create panoramas within museums as well as collating photos, videos and stories.

While this is effective and allows museums in Google's collection to have a massive digital platform to be presented from, the ability to manage content from the museums side, or have the content presented on the institution's site is not in Google's policy.

The praise and shortcomings of what virtual museums have been has been what we have based our research and development on to produce a web-based virtual museum resource for the EU funded project EU-LAC museums.

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The virtual museum can host digital content, such as 3D digitised objects, 360 degree virtual tours, virtual reality, and more traditional media such as photos, videos and audio.

The project was a global initiative for community museums, so a map interface visually connects all the participating museums. Both museums and content are discoverable and searchable from the map.

This gives it a user-friendly public facing front end that allows a user to explore digital content from all around the world and allows for comparison of objects and history between continental divides.

What was lacking in virtual museums designs we've implemented, such as a digital upload resource that allows for the museums themselves to create media and to publish it. After login, all content uploaded goes to the respective media platform within the site, is archived to our server, and produces a wiki that is editable by those logged into the site.

In conjunction with the virtual museum, we've produced regional mobile apps that use the uploaded media to create tours of the museums in that country.

What we've produced is a virtual museum that combines the functionality of an archive with a backend that allows upload, managements and storage, along with a public facing front end that "allows public access, presents knowledge in a coherent manner, and promotes preservation". Sounds familiar?

But this is not all what it can be. There's still a divide between the physical and the virtual. How can the content produced not just sit statically on the web or on a mobile app?

What we are currently researching and implementing into our virtual museum system is the ability for virtual representations in the physical museum. The content itself can be used in a museum setting, as we most recently have accomplished in the exhibition Picts & Pixels in the Perth Museum and Galleries, which had full digital integration from day one of exhibition planning.

But what if we could use the virtual museum archive, and pull the content from there, as opposed to moving the digital files around independently. That would enable for a whole digital aspect of an exhibition to be planned, constructed and used from the virtual museum itself.

And finally, now that technology has pressed further into the 3D and virtual realm, can we bring back the idea of what virtual museum representations used to be like? Maybe less clunky and pixelated.

By using augmented virtual reality, 3D digitisation, 360 degree photography and digital reconstructions, we can create a space where the actual 3D object can be interrogated and manipulated as well as compared to other similar objects from around the world. Imagine objects "on loan", but just digitally.

While the museum setting allows for comparison of objects within a collection, the initial physical environment has been stripped away and the object taken out of its original context. Within a virtual world built within a game engine, such as seen with Holyrood Abbey and Palace, the object can be placed back into its environment, perhaps enlightening people on its functionality and overall importance at that time.

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Real World Steps from Legacy Siloed Systems into Computer Mediated Reality

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1 Iran flight 655

July 3, 1988.

Somewhere in the Persian Gulf, nearby the strait of Ormuz, there was a flotilla of north American battleships sailing on patrol. Iran and Iraq were at war since 1981. Iranian gunboats had lately been attacking neutral oil tankers and US ships in the region and so US dispatched substantial Navy forces to the Gulf. One of the battleships dispatched was USS Vincennes, a very recent and high-tech guided-missile cruiser, equipped with AEGIS, the most advanced electronic combat management system (CMS), using the most advanced tracking radar technology at that time.

Broadly speaking, battleships have 2 main areas from where almost everything is controlled: The bridge, to manouver the ship and the CIC (Combat Information Center), typically a well protected room deep inside the battleship, from where all mission decisions and combat actions are taken. The CIC it's a computers room, the "brain" of the ship, usually operating in dimmed lights, with computer screens, radar screens, sonar screens, communications equipment, weapon firing controls, etc. Depending on the battleship type, size, alert status, mission, etc, some 15 to 30 military staff can be working in this highly secure room at any given time.

There are two major staff roles within the CIC: The Frontline staff in charge of collecting and analysing incoming data from radars, sonars, etc (air, surface, sub-surface, land) and to provide a complete and confirmed scenario to the Officials line, which in turn will take all decisions on ship manoeuvring, weapons engagement, mission next steps, etc, based on the reality that is presented to them, on their computer screens and audio.

So, it's July 3, 1988.

At a given point USS Vincennes got to know that Iranian gunboats were attacking neutral cargo vessels in their vicinity. To make a long story short USS Vincennes and another frigate maneuvered to intercept the gunboats and at a certain point got engaged with them. While involved in this gunfire USS Vincennes crossed Iranian waters. At 10:47 AM the radars in the CIC reported an Aircraft approaching the ship. Several actions taken to try to identify the aircraft (IFF, radio, EM, etc) were inconclusive at that point and so the air track was classified as "Unknown - Assumed Enemy". At 10:49 Vincennes warned the aircraft on military frequency with no response. At this point staff within the CIC believed the aircraft was an Iranian F-14 even though there was no positive confirmation of that. Warnings were repeated on both military and civilian frequencies and then the aircraft was warned it would be shut down at 20 nautical miles range unless change on its course.

At 10:53 Vincennes issued a final warning. At this point there was some confusion about whether the aircraft was climbing or descending…finally at 10:54 Capitan

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Rogers, the Capitan of USS Vincennes, gave the order to engage and fire two missiles to destroy the aircraft. The aircraft was destroyed. But was in fact a civilian airbus A-300 from Iran airlines, that took off from Bandar Abbas Airport in Iran with destination to Dubai, with 290 passengers and crew onboard. All died.

Later, a formal investigation to the incident ran by the US Navy, concluded that the disaster was caused by multiple Human behaviour and Machine behaviour contributing factors. On the Human side there was poor decision making and erroneous expectations and erroneous understanding, confusion, stress and team communication faillures during the 7 minutes of the event. On the Machines side there were deficiencies on the HMI of the AEGIS Combat system that ultimately led the military in charge to take the decision to bring down IR655.

As with any other tragedy there were many small details to this incident, a lot of small events and pieces of conflicting or missing information that contributed to the sad outcome. It's beyond the scope of our talk to dissect this incident. Our case in point is: during these 7 minutes of intense stress the state of the art Aegis combat system, operated by trained and highly disciplined professionals, was not enough to create an accurate picture of the reality "out there", humans and machines working together were not able to understand what was going on outside the ship. The staff, inside that dark room, experienced and lived an illusion, while experiencing very high levels of stress. The "computer mediated reality" created that day was… fictional.

But the outcomes were very real.

I'm bringing this very dramatic example because this is the type of mission-critical systems I've been working with for the past 15 years or so, this is to say, systems that may bring severe consequences to a lot of people if they fail. I will showcase a few from my own experience working with Critical-Software.

Also because it is a good example to discuss major concepts and concerns when you're designing computer mediated reality systems, e.g, systems with the goal to assist humans in understanding "reality" better: Situation Awareness, Recognition Primed Decision, Performance load, Cognitive Load, Mental Models, Scenario fulfilment and other bias, but above all on the importance of getting involved with real users trying to get the most clear understanding of what they are trying to accomplish in first place by actually meet them, spending time with them in their offices or work environments, getting to know their tools, their processes, their jobs, their mental models, their difficulties, their real scenarios of work... most of this by actually being "there", exposed and immersed into those same situations and spaces, together. This is the only way, to my experience, to minimize the ever present temptation to do self-design and to minimize the ever present HIPPO effect (Highest Paid Person Opinion).

2 The "Reality" Vs the "Virtual"

Before we dive in the concepts and examples I would like to discuss with you, I guess we need to pause to think a bit about what we usually understand as Reality and Virtuality. Common sense will say Reality is our body and the physical world around it. It's what we can "experience" with our "senses".

On the other side, virtuality is commonly understood as a synthetic reality, an immaterial alternative reality built with computers. We can enter and leave virtual realities at our own will because they do not exist "for real" and because they are controlled by humans, but we cannot escape our own physical Reality because our bodies exist on a very tangible space and time. On the physical Reality we need to eat,

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drink, get together, learn, work, sleep, and so on so we can actually persevere our own existence. On the physical reality if we die, we die for good. On a virtual reality we are set free of our physical bodies and so we can exist forever, be whoever we want to be, do whatever we wish.

Right? Well not so fast.

Remember Capitan Rogers and the crew at the USS Vincennes. For them reality was that there was an F-14 flying into them even though they could not physically see it with their own eyes. Feeling that they were a couple minutes from being attacked - and probably dead - they act accordingly to their military doctrine and also, probably, after their sense of self-preservation. Virtual and Physical Reality merge together in these environments and create a single reality that lives in people minds.

In fact, reality might just well be what we think that reality is…if we move into a reality that has no physical existence that will still be and feel to us just as “real” …

3 On Situation Awareness and Recognition Primed Decision

Situation Awareness has been defined as 3 stage mental process: 1- the perception of information coming from our environment, 2-the understanding of it’s meaning and 3- the mental projection of their state in the near future. For instance, we see a biker coming fast on the sidewalk, we understand that we´re on conflicting trajectories and we project we will collide in a few seconds. Based on that we can make a decision on how to act to avoid collision (moving aside, for instance, or stay put and hoping the biker will pass by us).

On the other side RPD is a human behaviour to make good enough decisions when facing complex situations making use of previous experiences - mostly in situations where time is of essence. As soon as a solution seems viable to us, given the pressure of time, most of us will follow it even though it may be a less than ideal course of action. For instance, a firemen will not look for the door keys beneath the doormat when trying to save people from a fire in an appartment building. He knows from previous similar situations that he needs to open that door as fast as he can, so kicking the door down - or using any readily available tool to bring the door down - is likely to be his first solution and that’s what he will try to do immediately.

These two concepts are critical to consider when designing mission-critical systems for human use. We need to make sure the systems we design are able to present accurate representations of the environment and - even better - help us in projection future states and help us deciding what to do next.

That was not the case with USS Vincennes. The Combat System was not able to provide crystal clear and unambiguous information about an air track (because it was not designed to do so) and pretty soon an illusory reality emerged in the minds of the crew. Given the pressure of time compression decision makers did what they were trained to do best: deciding quickly with the any available information and making use of their experiences, (e.g. Recognition Primed Decision)

We will go through an example of a system designed for a Major telecom operator in Portugal for their first line support, and a system designed for Battle Management for the army. Both trying to provide users with accurate and complete current information (the elements of the environment), trying to help users in understanding their meaning and also trying to project near future state, so then users can better decide on a course of action.

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4 Often Less is not More, when it comes to industrial mission-critical systems.

It may sound counter-intuitive: most industrial systems often need to process and display considerable amounts of data onscreen. Command and Control systems within control rooms in energy generation facilities, for instance, cannot be as simplistic as iPhone apps. But they need to present data in ways that are contextual and meaningful to their users, and above all, providing them with clear and accurate representations of reality, at all times.

We will go though the example of a system designed for monitoring traffic at sea, and also through the previously mentioned system designed for TELCO. Both provide extensive and contextual information and even more data on demand as users work with them.

5 Performance load, Kinematic load, Cognitive Load and the use of metaphors to decrease their levels

Cognitive load is the mental effort required to accomplish a task with success. Is the effort we make when reasoning trying to make sense of what we see and hear or otherwise feel.

Kinematic load is the physical effort we need to make to accomplish that task.

Performance load is the combination of the former two.

Designing a system for Mission planning for a military aircraft we faced questions such as “what would be a good solution for a pilot to handle fuel? what would be a good solution for a Loadmaster to handle cargo? what would be a good solution offering low levels of cognitive load to present tools for the pilot’s convenience and ease of use?”

Designing a system for water flow balance in a 3 hydraulic Dams system for a major Energy provider in Brazil we faced questions such as “how to simultaneously represent planned and current energy production in three different dams? their respective water flows, reservoir levels and water outputs? how to represent all of that along time, projecting the near future?

The solution for both systems was to use metaphors, images recognizable by its users, symbolic representations of their own realities, so that data onscreen could display in context and with improved meanings with less effort. We will go through both systems to further discuss these solutions.

6 Knowing reality is the only way to be able to design systems to represent…that reality.

Quick exercise on the fallacy and dangers of unproven or misinterpreted User / System requirements: We will try to design/think through a solution for a door for a spaceship.

Understanding what user are trying to accomplish is key and pretty much nothing else matters as much when you’re trying come up with solutions that will be useful and usable.

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Sure, there are times when we are given the opportunity to design systems that ourselves will be able to use. In those situations we can do self-design and pursue what we think is best. But those situations are very rare. We spend most of our time designing systems that will be used by people other than us, systems that we will never use ourselves. For instance I've worked extensively on systems for ophthalmology and I never got to use them myself…i'm not an ophthalmologist… none of the systems covered in this talk will ever be used by the teams that designed them and built them.

We will go through a few examples of onsite functional analysis as a way to better understand what system features shall we design and why.

7 VR interfaces, highly metaphoric, visually rich and microinteractions rich HMIs as an alternative to the mainstream two dimensional human-computer interfaces.

We live in a physical multi-dimensional world. We capture events that happen around us though our senses and we try to make sense of that with our brains and our bodies.

We have memories, past experiences, we learn by habituation and repetition. We make use of all of that for every single action we take, at all times.

Also our behaviour is often pretty much predictable since we often act after behavioural bias. We tend to complete narratives in our heads when data is missing (scenario completion), we tend to stick to the first course of action we can think of based on previous experiences (Recognition Primed Decision), we tend to look into available information to confirm an ideia or decision we've already made (confirmation bias), we tend to see patterns where there are none (apophenia), we tend to favour visually appealing tools (aesthetics-usability effect), etc.

It's only natural that we can relate well with computer mediated reality solutions, complementing and augmenting what we already can obtain through our own body sensors alone (eyes, ears, skin, nose, etc.).

Computer Mediated Reality has the potential to make narratives tangible and understandable onscreen in ways not available to orthodox Graphical Interfaces. The sense of time can be better exploited, by experiencing it rather than by trying to represent it in cartesian graphics and users mental models can be pursued better.

When designing our own CRM at Critical-Software, we got to speak with Business Developers, the population that would be using the new CRM. They spoke a lot about "Goals", "landscapes", "menaces", "opportunities", etc.

We will go through the software that was actually designed and built and also through some sketches on an alternative solution that was trying to create a Virtual Reality landscape where projects and goals and opportunities could be physically represented and where a narrative was immediately apparent.

That brings us to the question "what is a system feature on a computer mediated reality system?"

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Workplace-based Learning in the Industrie 4.0: Multi-perspective approaches and solutions for the shop floor

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Today's workplace on the shop floor (the area of a factory where operatives assemble products) is highly demanding. The foremost goal is to maintain productivity to fulfill customer orders by producing the required number of products. The environment is a highly complex one: the machines become ever more complex, as do the products. The increasing automation requires maintaining a highly fragile equilibrium to enable the machines to run without human intervention for as long periods of time as possible. Furthermore technological innovation results in new materials and new technologies being used in production and for processing and assembling products. Last but not least, a decreasing workforce requires employees to become more flexible and master larger number of skills, for instance to be able to stand in when colleagues are not available. This requires to use machines that are not the primary area of expertise. As a consequence, the employee is under constant pressure to solve problems occurring on the shop floor as fast as possible, and simultaneously to improve his work-related knowledge, skills, and capabilities.

This makes the shop floor an area where the usage of technology to support problem solving and learning of the employee can result in significant benefit. Especially the usage of adaptive technology methods based on artificial intelligence methods carries a high potential: ideally, the support is context-depend (based on the affected machine, its state, the current product) and adapted to the individual employee (capabilities, work history, development goals).

This keynote gives an overview on current research on how AI-based architectures and tools can support humans and organizations on their way towards Industry 4.0.

We will elaborate on context-sensitive and intelligent-adaptive assistance systems for knowledge and action support for Smart Production, which focus on the skills and competencies of the staff and attempts to compensate for any skills that may be lacking with respect to performing tasks at the workplace (action support). In addition, knowledge-support services facilitate the continuous expansion of staff expertise through the acquisition of knowledge and skills in relation to production, product, and process. Such services serve to promote the professional development of the staff so that they can gradually start to perform more demanding tasks and serve as a counterbalance to the demographic change and the shortage of skilled workers. We will give examples of practical implementations, including the setup and operation of a manufacturing unit in the production process, as well as the preventive maintenance, maintenance, and troubleshooting.

Similarly relevant is the question how practical knowledge about work processes can be recorded and made available. There again, AI-based tools can provide support, e.g., by ensuring the recorded content contains all the relevant information needed for learning. Again, we will give examples of what such an authoring tool can look like.

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Immersive Learning Research: a proposed design for an open networked global community effort

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Now entering its 4th year, The Immersive Learning Research Network (iLRN) continues to grow. The network is an international organization of developers, educators, and research professionals intent on collaborating to develop the scientific, technical, and applied potential of immersive learning, discovering "what works", and sharing it. With an annual worldwide conference featuring peer reviewed research papers from across Computer Science, Game Design, the Learning Sciences, and many other disciplines, iLRN is beginning to realize part of this mission – though it's really only a beginning if we are to be truly measured a success. There are a number of challenges before us – two of the most pressing being, "why should people collaborate and share their knowledge of what works?" and "how might that work in ways that benefit people – particularly those involved in doing the work?".

In this presentation, I'd like to engage you, the iLRN audience in the prospect of how and why you should work with iLRN to realize this vision of serving humanity by identifying what works, mapping it out, and providing people with clear access and understanding of how to contribute to and use immersive learning environments most effectively. iLRN, as an organization, recognizes that we need to better define what, indeed "immersive learning" really is, and we recognize that, because the contributions being made to emerging disciplinary areas come from a wide range of professional, scholarly, and other human dimensions of activity, we need to build meaningful "bridges" and techniques for working across these disciplines on common problems. The scope and impact of immersive learning environments is just beginning to be realized and iLRN is perhaps uniquely positioned as a mechanism for open access and scholarship. Innovation and effort, is of course, of paramount importance.

Our theme for this year's iLRN Conference is "*Grounded in Tradition, Immersed in the Future*". It's in deference to our fantastic location for the conference in Coimbra, Portugal, home of Universidade de Coimbra – a lovely place of learning, generally known as the 10th most venerable academic institution in the world – and our obvious connection to the fast-changing nature of learning because of these new innovative situated ecological learning capabilities.

Scholarship in the Middle Ages grew slowly from a conceptual framework that proposed a set of building blocks upon which the rest of rational thought could be constructed. The fact that it emerged and grew at all is quite remarkable. These scholars must have faced tremendous confusion, resistance, and political and financial obstacles. Yet they did it and they thrived by agreeing on a set of principles and collaborating over time to refine them.

The "Trivium" of logic, grammar, and rhetoric were the three basic building blocks for higher learning – the foundational three of the seven Liberal Arts. The Trivium's power rested on its consideration for how ideas entered, were processed, and exited the human mind. These "inputs, processes, and outputs" taught, essentially, critical thinking. When students had mastered the ability to that – taking information of

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any kind and carefully considering it through those lense, that then led to the other four – the "Quadrivium", of arithmetic, geometry, music, and astronomy.

Similarly, iLRN proposes, as a means to bring together the disparate scholarly and professional fields together to work together on this shared problem set of "Immersive Learning" to use three foundational building blocks that scholars must seriously consider and understand for Immersive Learning Environments to "work", that is: (1) Computer Science, (2) Game Design, and (3) the Learning Sciences. These three areas of human scholarship and applied understanding, though not easily understood as input-process-output are all essential to creating, researching, and evaluating Immersive Learning experiences of all kinds. From this tripartite foundation, the applied areas of "what works" in Immersive Learning may be deliberated on. Drawing on sensory, actional, and symbolic factors, Immersive Learning Environments digitally replicate the experience of location. Research has conclusively demonstrated that Immersive Learning can (4) Provide multiple perspectives; (5) Enhance or highlight key features (invisible, abstract, obscure) of ecologically complex systems; (6) Situate the learner; and (7) Enable transfer of difficult-to-understand information (Dede, 2009). These are the areas of evidence for why we should invest in immersive learning – why the expenditure of great time, money, and expertise is worth it. These are the proposed four areas of the Immersive "Quadrivium".

To operationalize this foundational framework, iLRN is launching a dedicated set of tools and services for scholars, developers, and professionals around the world that will support and extend these ideas:

- Build a knowledge base
- Collaborate on complex problems
- Identify the Pattern Language of Immersive Learning
- Showcase applications in applied contexts

Finally, in addition to mapping the landscape of "what we know" and creating a scholarly interchange for immersive learning across the foundational and applied areas where immersive learning is illuminating key understandings and phenomena, iLRN also proposes to

- Monitor and integrate innovation and change across the emerging landscape

Our new Environmental Scanning project will provide focus and timeliness to our work – giving context to the research by showcasing how things are chaning through publication of our Annual State of Immersive Learning Report, beginning this year 2017. Join us and let's scan the horizon, map the territory, and create new worlds.

Main Conference Papers

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Fieldscapes – Creating and Evaluating a 3D Virtual Fieldtrip System

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Abstract. This paper describes the concept of the virtual field trip and presents a taxonomy of virtual field-trip approaches. Building on the Virtual Skiddaw project between Daden Limited and The Open University, UK, the InnovateUK funded Virtual Fieldstrips as a Service project is described. The resulting Fieldscapes system is then presented, along with how it addresses the technical, pedagogic and commercial challenges of creating a virtual fieldtrip system. This is followed by an initial evaluation of the system, and areas for future development and research are identified.

Keywords. Virtual Field Trips, Immersive Learning, eLearning, Virtual Reality

1 Virtual Field Trips

Fieldwork, which involves leaving the classroom and engaging in teaching and learning through first-hand experience of phenomena out-of-doors, has a long tradition in geography and in certain sciences, notably biology and environmental science/studies. The concept of a virtual field-trip is well established [1,2] as a way of providing students with some knowledge (and virtual experience) of a location and how it demonstrates a topic under discussion without requiring them to physically visit the location, as well as being able to support and augment a physical field trip. However, there is a wide variety of technology which can be used to create a virtual field trip, and as a result there are differing perceptions as to what constitutes a proper (or effective) fieldtrip [3,4]. The range of technologies which can be used to create a virtual fieldtrip may include:

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- A set of images and video, used with a paper map
- A web based map linked to text, images, video and audio (e.g. Google Maps)
- A Geographic Information System with similar features to the above (e.g. ESRI - http://edcommunity.esri.com/)
- A video stream or recording of someone at the location (e.g. FieldTripZoom – www.fieldtripzoom.com)
- A set of 180° or 360° panorama photos
- A set of 360° "photospheres", (e.g. Google Expeditions - https://www.google.co.uk/edu/expeditions/)
- A 3D model examined from an objective perspective (e.g. Google Earth)
- A 3D model examined from a subjective perspective – i.e. the user represented as an avatar (e.g. Second Life – www.secondlife.com)

To provide a better framework for considering virtual field-trips the authors have developed the landscape presented in Figure 1 below. This identifies the two most important features of virtual field trips, as identified by the authors, as being:

- The extent to which the landscape is modelled in 3D in order that the true morphology and spatial relationships on the ground can be presented and understood.
- The extent to which the student has the same degree of agency as they do in a real field trip – e.g. can they go off-script and just run up the nearest hill?

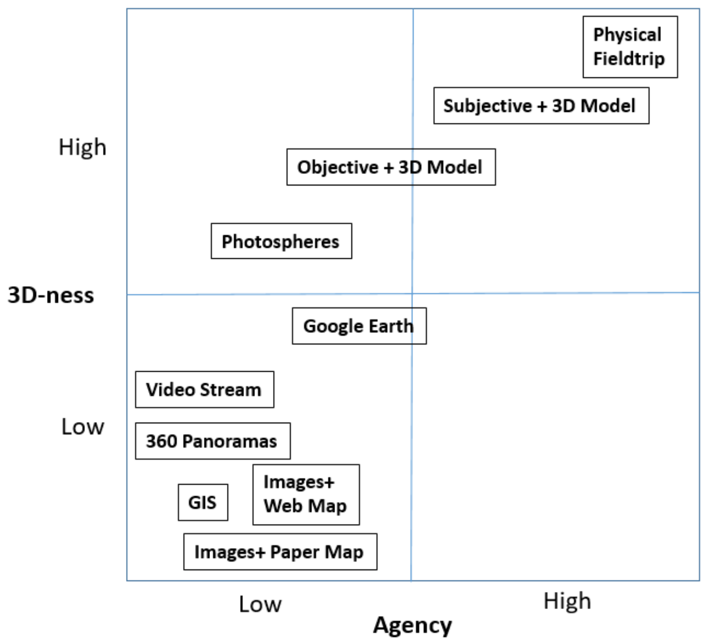

Fig. 1. A Virtual Fieldtrip Landscape

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Interactivity is assumed to be incorporated within agency – although there is not a strict correlation. Other possible dimensions which could also be considered include:

- Whether the virtual fieldtrip system supports multi-user use (as with a physical field trip).
- Ability of tutors to create their own content (as with a physical field trip).
- Level of immersion.

Within the project team there has always been a keen interest in the subjective experience within 3D modelled environments. This has come from using subjective 3D environments such as Second Life (www.secondlife.com) in a range of learning situations [5,6]. This interest, and a desire with The Open University (OU) to move beyond an images and paper map model for their own geology virtual field trips led to the Virtual Skiddaw project (http://www.open.ac.uk/researchprojects/open-science/3d-virtual-geology-field-trip).

2 Virtual Skiddaw

The aim of the Virtual Skiddaw project [7] was to create a subjective, multi-user 3D virtual field trip of the Skiddaw area in the English Lake District which could be used by OU staff and students to conduct synchronous, group-based, virtual fieldtrips – and therefore conducted in a very similar way to physical field-trips. This would help the OU move from an Images+Map approach (bottom left quadrant in Figure 1) to a Subjective 3D Model (top-right quadrant). Daden Limited created the Virtual Skiddaw system using the Unity game engine, and with commercially sourced digital elevation data and aerial photography. Six specific sites (and hand samples at each site) were digitally captured using photogrammetry. The resulting 3D model gave accuracies of around 2-5m across the whole 10km x 10km area, and of around a few centimeters in the sample sites, and of millimeters for the hand samples. Pedagogically, the application provided the students with a text and audio overview of the location and its geology, a simple kit selection task, and then guided activities at the 6 sites which included: sketching the location, examining rock outcrops, examining and assessing the hand sample, and considering the location context. Virtual Skiddaw has been (and continues to be) used successfully on OU Geology courses since its development.

3 Virtual Fieldtrips as a Service

Whilst Virtual Skiddaw was an undoubted success the project team were keen to explore how the system could be moved from one institution/one location/one lesson to multiple institutions/multiple locations and multiple lessons.

In 2014, InnovateUK (the Innovation Agency of the UK Government) launched a Design for Impact competition to fund feasibility, and possibly development, of education technologies which had been proved on a small scale but which if scaled-up could benefit UK education (at all levels) as a whole. Daden led a consortium consisting of

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the Open University, the Field Studies Council (FSC, who host over 140,000 students on physical field trips each year), and DesignThinkersUK (a service design consultancy) and were successful at winning both 6 months Phase 1 Feasibility funding and then 12 months Phase 2 development funding. This paper presents the results of both these phases.

During both phases the project team actively involved a wide range of stakeholders, including schools, universities, field study operators, heritage organisations, mapping agencies, educational publishers and awarding bodies. DesignThinkersUK facilitated service design workshops in schools and with the FSC - to identify customer journeys. Workshops were also held at universities and even in Second Life.

The activities were broadly grouped into 3 main areas: pedagogy, technical development and commercial planning.

3.1 Pedagogical Challenges

In order to ensure that the virtual field-trip system was going to be of interest and use to teachers and students it was vitally important to understand what physical field-trips consisted of, how they were managed and experienced from both the teacher and students' viewpoint, and the role that a virtual field-trip could play in enhancing them. It should be noted that an over-riding feature of the project was that virtual fieldtrips should be seen as enhancing physical field-trips rather than replacing them.

From the workshops the team identified that a field-trip could be considered as having three main phases: before the trip, during the trip, and after the trip. Table 1 shows the different ways in which a virtual field-trip could be used to support the physical field-trip which were identified at these workshops.

Before	**During**	**After**
Teacher planning/skills Student skills/planning – maximise time-on-site On site meeting with field tutors Parent briefing Risk assessment General map skills Context setting	Next-day planning "Virtual drone" on site Where we didn't get to…. Wet-weather programme Day review	Data review Students who missed trip Students who didn't do all tasks Comparative sites Translation tasks Revision

Table 1. The Before-During-After roles of a Virtual Field Trip

Whilst the discussions were focused around "environmental" field-trips (including geology, geography, earth sciences, environmental studies, biology) almost all educators identified the wider opportunities that such a system could offer to the teaching of history, Science, Technology, Engineering and Maths (STEM) subjects, and even languages.

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In addition, it became apparent that the technology itself needed to be pedagogically neutral – allowing educators to create the sort of lesson they wanted – whether structured or unstructured, directed or action learning etc. Most of the field trip systems described earlier embed the pedagogy within the technology application – resulting in systems that are inflexible when it comes to meeting individual educators' needs and approaches.

3.2 Technical Challenges and Development

In terms of the technical development of the system the workshops helped identify several challenges that any service needed to address, including how the system could:

- Deliver a wide variety of complex 3D terrain models.
- Operate on a variety of computing devices, including PCs, tablets and smartphones.
- Operate both in a "traditional" 3D mode (e.g. with the student represented as an avatar and viewed in first or third person), and with the new generation of virtual reality headsets (such as Google Cardboard and Oculus Rift).
- Enable teachers to create lessons without a high level of IT or 3D skills.

These represent the core requirements of the system, and the resulting Fieldscapes system developed as part of the project and described below has been designed to address and deliver against each of these challenges and requirements.

In order to gain some early technical feedback and experience the team created two demonstrator virtual field-trip applications and placed them on the Android Play Store and sent them to participating schools. Both ran on Android smartphones and were designed to be used with the Google Cardboard mobile Virtual Reality (VR) headset. The applications were:

- A 3D model of CardingMill Valley, a popular physical fieldtrip site in Shropshire, England, which allowed the user to walk and fly around a 2km x 2km area centered on the fieldtrip site. This let students see the context of the valley (which they do not typically leave during a trip) by flying all around it and the surrounding ridges and moors, and could even be used when physically on the field-trip in the valley itself. An image of the system is at Figure 2.
- A set of 3 photospheres (360° photos) which gave students an all-around photorealistic view of the valley at 3 key points, and the ability to "jump" between the points. The graphic quality was significantly better than the 3D model, but the student was significant limited in terms of where they could go – just 3 locations. An image of the system is at Figure 3.

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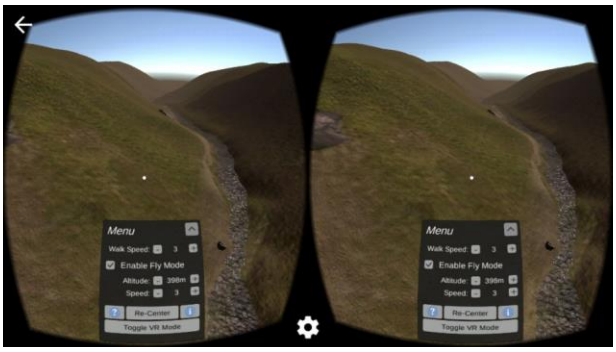

Fig. 2. The 3D Model of CardingMill VR Application

Fig. 3. The Photosphere CardingMill VR Application

It should be noted that neither application had any authored learning content beyond the location itself. The results of an evaluation of each is presented below.

In terms of system design the key decision was to separate the system out into 3 main elements:

- A “player “ application which initially contains no location or learning content, but includes an “engine” to deliver the learning content.
- The 3D files for each location, and any objects needed by the lesson, which are served to the player application when the student needs them, and then cached for off-line access.
- The learning content, defined in a platform neutral XML format, with a supporting what-you-see-is-what-you-get (WYSIWYG) and form based editor, and which again is served to the student as required.

This approach gives the system the flexibility it needs to meet the differing demands of student devices, the use of VR headsets, and to deliver a wide variety of pedagogical approaches for subjects from across the whole curriculum.

The resulting Fieldscapes system is described in more detail below.

DOI: https://doi.org/10.3217/978-3-85125-530-0-09

3.3 Commercial Planning

In the discussions with educators it was apparent that in order to be useful a virtual fieldtrip system had to be able to deliver content that was specific to the curriculum being studied (rather than a "general" geology field-trip), and had to be applicable across the whole-school if the money was to be made available to purchase it.

Commercially there is no way that Daden (or most other small companies) can afford the investment to create such a wide variety of lessons up-front. The only feasible route, and the one adopted by Fieldscapes, is to create a sharing culture of User Generated Content. The Times Education Supplement TES Resources site (https://www.tes.com/teaching-resources) has shown just how readily educators will create and share quality content.

The other key commercial consideration was pricing. The teams' experiences with the educational users of Second Life have shown how educators like to be able to "play" with a technology and experiment before using it in class. The Second Life pricing model also showed how the high cost of subscriptions put off small-scale use of the platform – which may have in due course led to whole-institution use. For that reason Fieldscapes is being developed with both a "educator access free" model to encourage experimentation and then a tiered "per student" charging model to enable the system to be economically viable for any size of class or institution.

It should also be noted that the team was well aware that child-safety concerns around Second Life restricted its use in schools and Fieldscapes has been designed to address these concerns and provide a safe environment for 3D immersive education.

4 Fieldscapes

The Fieldscapes system developed through the project is shown in Figure 4. The main elements of the system are:

- The Fieldscapes service (centre of Figure 4), which runs on the Internet and is used to host locations, inventories and exercises
- 3D location and equipment models (top of Figure 4), created by anybody with suitable technical skill and developed with industry standard tools such as 3D Studio Max, SketchUp and Unity3D.
- Exercises (right of Figure 4), which almost any IT-literate teacher should be able to create. Exercises are defined within a location simply by moving around, placing objects (called "props" in Feldscapes, and defining how the user interacts with those props. The authoring tool provides variables, logic tests, timers, grouping of props and media integration by URL to create a relatively rich authoring environment.
- The Explorer application (bottom of Figure 4), which lets students undertake the exercises and comes in versions that run on Smartphones and Tablets (iOS and Android), and on standard PCs (and shortly Macs). In terms of virtual reality (VR), the iOS and Android versions support Google Cardboard, and the PC/Windows version supports Oculus Rift. The Explorer application can also work in single user or hybrid

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multi-user mode, and also provides class management tools for a tutor – such as recalling the class from across the landscape (and then locking them in position!)
- The Lesson Manager application, which as well as allocating students and exercises to assignments also tracks student completion and success on each assignment, and interfaces to a Virtual Learning Environment (VLE) (left of Figure 4).

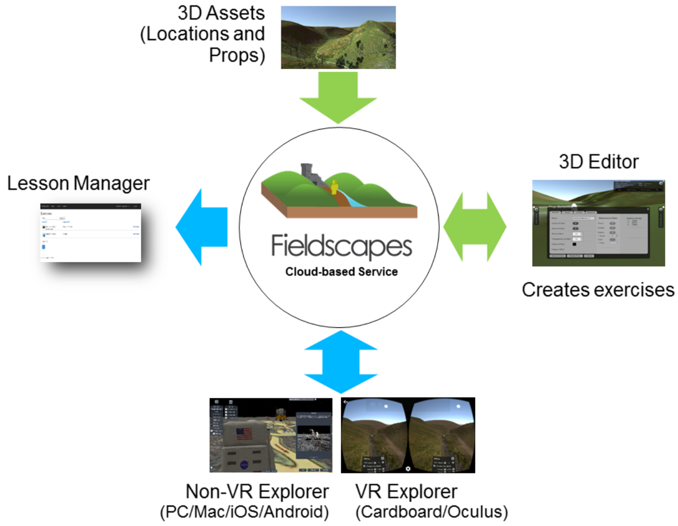

Fig. 4. The Fieldscapes System

An image of the Fieldscapes authoring environment is shown in Figure 5, and Figure 6 shows the user experience during a river measurement exercise. A video introduction to the Fieldscapes system is at https://www.youtube.com/watch?v=vCrstN4tlFg, and there is more information on the system at www.fieldscapesvr.com.

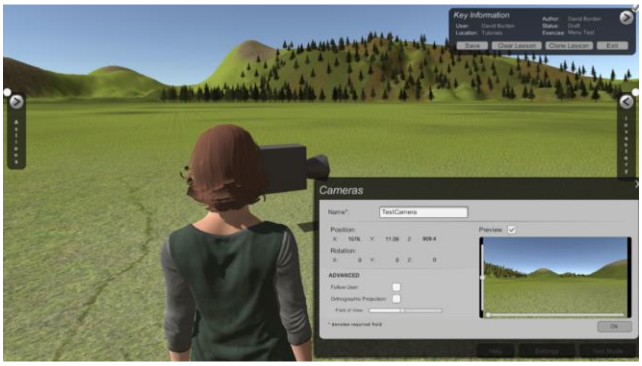

Fig. 5. The Fieldscapes Editor

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Fig. 6. The Fieldscapes User Experience

5 Initial Evaluation

During the Phase 2 activity the project team undertook a variety of very initial qualitative and quantitative assessments of Fieldscapes as part of the school, university and stakeholder engagements to help prove that a virtual field trip can aid learning, and, in particular, support students going on a physical trip. Further work is on-going but the initial results are presented here.

5.1 Qualitative Assessment

From the workshops and trials session the following quote give an idea of how well the Fieldscapes concept and application were received:

"This is ridiculously exciting. People have been using the term virtual fieldwork for a while but this is the first actual virtual fieldwork I've seen. Mind blowing!" – Geography Teacher, Melbourne, Australia

"I presented to 3 other earth science teachers, the head of science, and the administrator in charge of science this morning. They all loved Fieldscapes." – Geology & Paleontology Teacher, Virgina, USA

Negative comments tended to dwell on the lack of visual realism in comparison to photospheres, current lack of avatar choice, and current lack of browser access.

5.2 Quantitative Assessment

As an example of the quantitative assessment undertaken the results presented here are for a workshop held at a girl's secondary school in Northampton. During a one-hour

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session 20 students took part in a round-robin of 4 stands with each student having the chance to try out:

- The Photosphere VR of Carding Mill Valley (CMV) running on Google Cardboard (top left quadrant of Figure 1).
- The 3D Model VR of CMV running on Google Cardboard (top right quadrant).
- A lesson on Apollo 11 running on a PC using Fieldscapes (top right quadrant).
- A lesson on tourism in CMV on a PC using Fieldscapes (top right quadrant).

Students were then asked to rate each system by:

- How much they felt they learnt (self-assessed on a scale of 1 to 5).
- How much they felt that it prepared them for a physical field-trip to Carding Mill Valley that they were undertaking the next week (self-assessed on a scale of 1 to 5).

The charts at Fig 7 show the results for each of the 4 systems against these two measures (N=20, HPS=5).

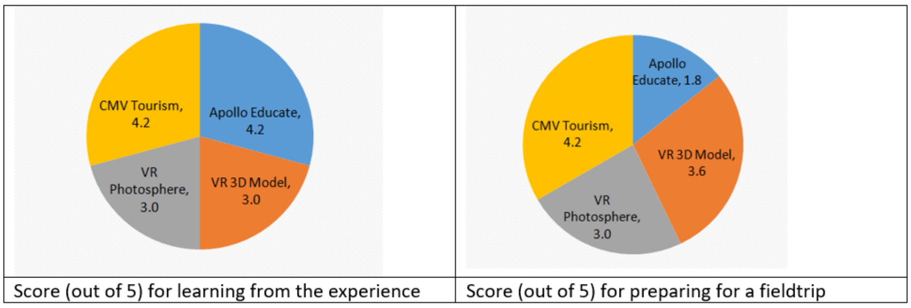

Fig. 7. Average efficacy ratings for different virtual fieldtrip models

The key findings were:

- Students felt that they learnt well, from the Apollo and Carding Mill Tourism exercises, and with equal performance.
- The students gave two Cardboard VR applications lower learning ratings – but it should be noted that neither had an explicit learning layer.
- The Tourism exercise scored highly for preparation for a field trip – the expected result as it combined a full 3D model, a high level of agency, and a structured learning layer.
- The VR 3D model scored more highly than the more photo-realistic VR photosphere – again not surprising as the 3D model enabled the students to better place the valley in context, and to visit any part of the valley.
- The field-trip to the moon was poor preparation for a physical fieldtrip to Shropshire!

Overall, the results of this quantitative assessment confirmed the validity of the design approach for Fieldscapes and the focus on a good quality 3D model and high student

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agency in order to place the virtual field trip as close to the physical field trip experience in the top-right quadrant of the earlier Figure 1 as possible. As the use of Fieldscapes grows we would hope to complete a fuller evaluation of this type with more students and a wider set of questions.

6 Future Directions

With the completion of the InnovateUK funded work in October 2016 the development of Fieldscapes is now being undertaken as a self-funded activity by Daden, and the project partners are continuing to provide active support.

6.1 Commercial Development

Fieldscapes is currently in beta, with beta-testers already coming from across 3 continents. Beta testing and content development is planned to continue until Feb 2017 when the system will be formally launched for live use.

6.2 Technical Development

The initial launch system will support all the key features that the project has shown are needed in a baseline virtual fieldtrip system. It will run on PC and Android systems, and Oculus Rift VR headsets. Further development will be driven by user demand and feedback and is likely to include versions for the Mac, support for other VR headsets, and support for data visualization within locations, and possibly web browser access.

The team is also considering the publication of the XML standard used for exercise definition as an open standard which may open up alternate uses for the system, and the ability for third parties to create editors and players for Fieldscapes exercises in environments not being directly supported by Daden.

6.3 Research

The project team is keen to conduct further research into the efficacy and longevity of education and training within immersive 3D environments, and comparison between avatar-driven and “VR” style approaches to virtual fieldtrips and immersive learning, the efficacy of different pedagogic approaches within 3D and VR immersive learning environments, and the strength of encoding specificity [8] in simulated environments.

7 Conclusions

Fieldscapes represents the culmination of over 10 years of experience in both Daden-Limited and the Open University in the development of immersive learning experiences and environments. To us the fully realized 3D model of an environment, together with the highest level of user agency (and ideally a multi-user setting) provides the closest

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possible experience to a physical field-trip – and as such is ideally positioned to complement and extend physical field-trips, and to allow students to undertake trips and exercises which are just not practicable in real life. This is certainly not to say that a 3D model based field-trip is better than other forms, and educators should always be aware of the affordances of the different approaches (GIS/Google Maps, Photospheres/Google Expeditions) and use them accordingly.

There are undoubtedly challenges in deploying such technology in the classroom – from technical issues such as PC graphics power, locked down desktops and network bandwidth, to issues of staff training and time to just experiment with new approaches with their classes. Certainly, from our experiences over the last 12 months, the technical issues have much reduced over the last decade, but the latter "soft" issues are as challenging as ever.

Through separating the technically challenging task of creating the 3D environment models from the pedagogically creative task of authoring exercises and experiences, and by providing a child-safe learning environment, we also believe that Fieldscapes could help to significantly democratise the adoption of 3D (and VR) immersive learning within the classroom.

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Enhancing foreign language learning in 3D immersive worlds – a study report

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Abstract. The popularity of 3D virtual worlds among 'massive' users has decreased within the last five years – this is the fact. However, they seem not to lose much of their educational value as learning and teaching environments.
The article describes a 3-step project on educational functionality of 3D immersive virtual environments that was/is performed at Adam Mickiewicz University (AMU) in Poznań, Poland: Main Project One in 2011-2012, current Mid-Project in this academic year 2016-2017, and Main Project Two in 2017-2018. This year's edition (Mid-Project) uses some of the methodology of the previous Main Study and serves as a mid-stage before the next large research project which is scheduled for the next academic year 2017-18. All the three projects focus mainly on foreign language learning in serious virtual worlds, though the study is performed within the ICT class among students of humanities.
This academic year's mid-stage study has involved so far (the Fall semester) 60 students at AMU in Poznań, Poland, too. The students were involved in different learning and communicative activities in the virtual world of Second Life. They took some formal and informal foreign language classes in two destinations in Second Life where volunteer teachers give classes free of charge. They took part in the so-called 3D classes run by the author. They also explored the world of Second Life in search of potential educationally functional places for foreign language learning. The students performed their activities both individually and in teamwork. Similar activities are planned for the Spring semester, which just started in February. Here, a group of another 60 students are involved now. The next 60 are planned for the second half of the semester.
The article presents a general overview of the three stages. It includes: (1) a description of the activities and methodology used in Main Project One, (2) a short report from the current Mid-Stage Project together with results gathered so far and conclusions, and (3) some implications for the next year's Main Project Two.

Keywords: immersive education, virtual worlds, situated learning, foreign language learning, higher education, Second Life, action research.

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1 Introduction

Three-dimensional virtual worlds gained their popularity throughout the first decade of the 21st century. Many kinds of worlds came into being: games and non-games, all-purpose and serving specific purposes, worlds for kids and adults, etc. In this article, we will focus on the so-called ‘serious’ immersive worlds, i.e. environments that are not games [see: Freitas 2008]. Second Life is still the largest world in this category. It is not a game, at least not a central game, as it does not fulfill the characteristic features of a game: there are no pre-programmed scenarios to follow, no consecutive levels to reach, no forfeits to collect, no scores, etc. A serious virtual world simply IS: with its towns and villages, houses and fields, hills and islands – all raised by the users/residents themselves [Topol 2016b, p. 73]. Residents stay inworld for their own reasons, whichever they are: for fun, business, entertainment, trade, work, education… [compare: Leigh, 2014, Chapter 1].

Second Life did not fully prove functional as an all-purpose social environment. Its popularity started decreasing with the turn of the first and second decade of the 21st century. The reasons were different. Many users withdrew due to technical difficulties. First, the application required high-quality hardware: a fast processor, an efficient graphics card and broadband access to the internet. Others gave up because of the steep learning curve in handling the software: moving the avatar simultaneously with controlling the camera, the text chat, the voice channel, pop-up windows, and the SL browser menus [see: *technical and competency threshold* in: Warburton, 2008]. Many left Second Life for applications like Facebook, which, as social environments, served their needs better. The total number of accounts in Second Life is estimated approximately 40 million nowadays, however, Linden Labs, the owner of SL, do not reveal how many of them are active users.

The educational sector seems to be unthreatened. Many universities and schools maintain their virtual campuses. It is true that a number of educational institutions as well as individual educators have given up Second Life, however, many of them not because of poor educational functionality of SL but mostly because of costs. Linden Labs decided to cancel its 50% land-owning discount for educational and non-profit institutions in the year 2010. Some institutions simply could not afford the high rent to own land, in Poland, too[1].

The following parts of the article give brief descriptions of research projects on Second Life, performed at the Faculty of Educational Studies at Adam Mickiewicz University in Poznań, Poland. All the three projects deal with the educational functionality of serious virtual worlds in foreign language learning. The Faculty has never owned land in SL. Actually, the experiment did not require putting up a virtual campus. The projects made use of numerous open-access and free-access spots across the virtual world [see: the social context in language learning in VW’s in: Lan, 2015, p. 17].

[1] The Faculty of Arts at Maria Curie-Skłodowska University in Lublin, Poland used to run their virtual campus up till 2011.

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2 Initial Project (Main Stage One)

Three-dimensional serious virtual worlds are and have been little known in Poland – among educational institutions as well as educators and students. Hence the idea of measuring its functionality in academic education in Poland. The Stage One project was organized in the academic year 2011-2012 and lasted the whole semester. It involved 70 students of humanities at the Faculty of Educational Studies at AMU.

The aim of the study was to measure the students' achievements in language learning in 3D serious virtual worlds on the example of Second Life. There were two specific goals: (1) to measure students' achievements in their language learning, and (2) to measure students' emotions, motivations and opinions about SL as a learning environment.

The methodology covered different techniques and tools, as the students were involved in various activities [Topol, 2016a, p. 47]. The main part was a classical pedagogical experiment with control and experimental groups. Two virtual environments were examined and compared: the 3D virtual world and 2D WWW spaces in language learning. The rotation method was applied: the experimental and control groups switched in the middle of the experiment.

The project was actually divided into three parts: (A) culture part – pedagogical experiment – where the students collected data on culture and lifestyle, (B) language part where the students took part in formal and informal foreign language classes (English and/or German, according their language courses at AMU), and (C) exploration part where they visited cultural centers (Second British Council and Second Goethe Institut). They also explored the world of Second Life in search of educationally functional locations.

2.1 Part A

In Part A, the students in the experimental groups performed individually in two main tasks in Second Life. Task one was to visit the virtual replica of real life Dresden Gallery. The students were asked to walk around and get to know the building, the rooms and some paintings. They had to find the exhibition of paintings by Canaletto. The task was to collect data about Canaletto and his pictures by interacting with the exhibits. Task two was virtual shopping: the students were asked to visit virtual emporia in Second Life and plan how to equip their hypothetical apartments.

The control groups did the same in both tasks but used WWW for data collection. The tasks were organized the way that control and experimental groups did not interfere with each other, i.e. they performed their tasks at different times. The reason was that the groups would not contact each other while performing their tasks.

The students' language gain was measured with vocabulary tests (multiple choice and sentence building in meaningful contexts). The students' cultural gain was measured with knowledge tests that included closed, semi-closed and open questions. Both control and experimental groups received the same tests and questionnaires.

DOI: https://doi.org/10.3217/978-3-85125-530-0-10

Table 1. Part A. Student tasks in the pedagogical experiment for the control and experimental groups

Category / Objective	**Experimental groups (3D environment)**	**Control groups (2D environment)**
Culture gain and language gain / Please collect information about Canaletto, his paintings and Dresden Gallery.	Visit Dresden Gallery in Second Life and explore it. Walk around, read the descriptions and collect the information.	Browse the web or other electronic resources for information about the painter, his paintings and Dresden Gallery itself.
Language gain / Please plan how to equip your house (apartment) with furniture and items.	Shopping task in English Village in Second Life. Walk, talk and shop. (simulation)	Shopping task in online WWW shops, excluding auctions. (simulation)

2.2 Parts B and C

Part B was devoted to formal and informal foreign language classes in Second Life. All students were involved – both from experimental and control groups. They were send to two main language learning islands in Second Life: Virtlantis and Cypris Chat (known also as Cypris Village). They had to familiarize with class schedules there and choose one or two classes per each island to take part in. They could participate in the selected classes individually or in small groups of three to five. The students received special forms to fill after each class. They gave short reports with reference to the content of the class, the teaching methods, the atmosphere, interaction, and the virtual environment itself. At the end of Part B, the students' language gain was again measured with vocabulary tests.

Part C was teamwork. All students formed small teams of 3-4 people. First, they were asked to visit and explore the islands of British Council and Goethe Institut in Second Life. One could find general information about the mission of both institutions, as well as walk around and play with language due to some interactive 3D installations there. The teams then shared their experiences and impressions with the other students in class discussions at AMU. Second, each team was to explore the world of Second Life in search of places that – in their opinions – would be potentially functional for language learning, for culture gain or in general education [comp.: Topol, 2015].

Each team developed a PowerPoint presentation which they then presented in front of the other students in class at AMU. The presentations were supposed to include: a short description of the place, the SLURL, some pictures taken inworld and a few reasons why they recommended that place.

DOI: https://doi.org/10.3217/978-3-85125-530-0-10

Table 2. Selection of tasks in Parts B and C.

Category	Task	Output
Exploring Culture Islands, Individual task	Individual exploring the islands of the British Council and Goethe Institut in Second Life. Walking, gathering information, playing with language on interactive virtual objects (virtual worlds as a culture learning environment)	• Individual written reports: descriptions and open questions. • Group debates and individual interviews.
Language lessons, individual tasks	Joining a given number of lessons of English or German at Virtlantis and Cypris Chat in Second Life. (virtual world for learning language skills)	As above
„Class3D" by Pawlus Twine[2], group participation	Each of the 6 groups joined lessons of English that take the most of the immersive environment of a virtual world (Second Life): holodecks, interaction with objects, etc.	Survey, comparing virtual classes to their physical life language classes at AMU.
Exploring SL, team work	In search of places of potential educational functionality in Second Life – for foreign language learning as well as general education or specific educational purposes	• 3-4 people teams explore SL. • Teams give PPT presentations to their groups.

2.3 Methodology of examining educational functionality[3]

The author developed a four-category typology of functionality with reference to immersive virtual environments [Topol, 2013, p. 147-174]. The typology includes:

1. **cognitional** and **instructional** functionality,

[2] Author's name in Second Life.

[3] Both the methodology and the statistical analysis were presented at two virtual conferences (not in print):

VWBPE 2013: "Virtual Worlds – Best Practices in Education" – a worldwide virtual conference which takes place in Second Life, OpenSim and other serious virtual worlds [https://vwbpe.org];

"7th SLANUGAGES Annual Symposium" on language learning in virtual worlds. Venue: EduNation in Second Life, Feb. 28 – Mar. 1, 2014. The video recording available at: http://youtu.be/LtypiX0WMgs or https://www.youtube.com/watch?v=LtypiX0WMgs.

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2. **emotional** and **motivational** functionality,
3. **performative** and **interactive** functionality,
4. **technical** and **tool** functionality.

Each of the four categories was divided into two sub-categories. The research hypotheses were based on those eight sub-categories:

1. *cognitional and instructional:*
   (a) cultural-cognitional functionality: students will have higher culture gain in 3D than in 2D learning environments,
   (b) effective functionality: students will have higher language gain in 3D than in 2D learning environments,
2. *emotional and motivational:*
   (a) students will have higher emotional impressions from 3D environments (and from learning there) than from 2D learning environments,
   (b) students will declare higher motivation when performing learning tasks in 3D than in 2D learning environments,
3. *performative and interactive:*
   (a) students will give higher value to the virtual world as an environment for educational tasks and linguistic activeness during lessons. Studens will prefer voice to text communication in group classes (language lessons),
   (b) students will assess positively the VW as a socio-interactive environment in language learning tasks,
4. *technical and tool:*
   (a) students will estimate the technical threshold of Second Life on the medium level (getting around in SL, avatar movement, etc.),
   (b) students will estimate the tool threshold of SL browser on the high level (interface functionality).

Each sub-category was divided into two consecutive elements. That allowed to distinguish as many as 16 variables in the study.

Data collecting went threefold through:

- tests and quizzes (for measuring the students' achievements),
- questionnaires (for estimating the students' motivation, emotions and opinions),
- group (panel) discussions and individual interviews (for gathering the students' personal reflections from the virtual world).

2.4 Results and statistical analysis

The majority of the hypotheses (based on the 16 variables) confirmed the virtual world of Second Life to be educationally functional among the group of 70 Polish students:

- Second Life proved as a functional learning environment among Polish students of humanities,

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- Second Life proved as a functional environment and teacher's tool in language teaching,
- Second Life proved as a successful environment in the light of Albert Bandura's Social Learning Theory,
- Second Life proved as a successful environment in the light of Jerome Bruner's Psycho-Cultural Approach to learning.

The data was processed statistically with the use of the Statistica package. The statistical analysis used t-tests of significance of differences mean, based on Student's t-distribution. The significance level was set at the level accepted in social sciences, i.e. alpha = 0.05. The results were statistically significant (**in most cases p<0,005**) [4].

3 Current mid-Project

This year's project is a mid-stage study. It is a natural continuation of the Initial Main Project. The aim is/was – again – to study the educational functionality of serious virtual worlds in language learning on the example of Second Life [enhanced by other research studies, e.g. Paillat, 2014). The data collected would help to design the Main Project Stage Two, planned for the academic year 2017-2018.

The current Mid-Stage project started last November and will last till the end of the current academic year. Actually, they are three independent sub-projects due to the organization of the academic year. The length of ICT class is half semester this year. Some groups take it in the first half, the other in the second half of each semester. The project started last November – in the middle of the Fall semester. Thus, only groups from the second half could be involved. So far, four groups of approximately 15 students each have taken part in the current study (November – January), which made the total of N=60. The Spring semester has just started at AMU. Here, the project will cover both halves, so the number will be doubled. The total number of participants in the Mid-Stage 2016-2017 will then make approximately N=160.

3.1 Description

The current study uses some of the methodology of the 2011-2012 edition. This year, the students' activities include the following:

1. **Task Class1**. Obligatory participation in scheduled foreign language classes (English in most cases) on the two dedicated islands in SL: Virtlantis and Cypris Chat. As it was mentioned above, the two islands offer language classes free of charge. Their schedules are quite rich – classes are offered practically every day. They cover different aspects of language learning and different subjects: there are typical grammar and vocabulary lessons, discussions on current world events, language and arts, *ad hoc* free conversing and many others. Students can also choose between different

[4] A detailed description of the methodology and the experiment itself were presented in three chapters in the author's book [Topol, 2013, pp. 290-373].

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levels of difficulty: from beginners to upper-intermediate and occasionally advanced. The students were free to choose types of classes according to their preferences, however, obligatorily one class at Virtlantis and one at Cypris Chat.

The aim of Class1 task was to engage the students in scheduled foreign language lessons. The students will then summarize the lessons, describe their activities during class at AMU and give their opinions about the SL islands as learning environments.

2. **Task Class3D**. Participation in author's class of English. The aim of the task is to make the most of the 3D environment of the virtual world to enhance learning. The author leads the classes at Virtlantis and uses the holodecks there (holodecks are *ad hoc* rezzed sceneries adequate to the topic of the class). The model class is "The apartment" where a holodeck of a penthouse apartment is rezzed for the students to explore. Each group of students is divided into 3-4 people teams. Each team has a different task to perform (e.g. to describe the sleeping room to the whole of the group, to look into the fridge and discuss the menu for tonight's hypothetical dinner, to discuss possible refurnishing of the living room, etc.).

The aim of Class3D is to show to the students how the 3D environment could be used to enhance learning. The students are supposed to interact directly with the environment (inworld objects) and perform in the immersive three-dimensional setting. Then the students will compare the 3D class with their regular English classes in traditional classrooms in the physical world.

Fig. 1. Class3D: "Apartment". Myself in the center and students around exploring the kitchen. The menu for a hypothetical dinner tonight will be discussed. (picture taken by author)

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3. **Task ExploreSL**. Each group of students are divided into 4-5 people teams. Each team is to explore the virtual world of Second Life in search of places which (in the opinions of the students) would be educationally functional in foreign language learning. The students are free to explore SL on their own, or they can use the *Destination Guide* available on SL homepage. The teams are free to divide responsibilities within the team. They can explore SL together or individually.

The aim of ExploreSL is to let the students wander across the virtual world on their own. Once they find a spot in SL they agree on to be functional in language learning, they are supposed to share their findings with the other teams within their group.

3.2 Data collection

1. **Task Class1**. The students were asked to take an active part in language classes and then fill a special form which included a short description/report of the class, together with the students' opinions and reflections. The students brought their filled paper forms to the class at AMU. First, an open debate was performed where the students could share their experiences from the language classes. Then, the author collected their forms for further analysis. Additionally, the students filled an anonymous questionnaire which measured their opinions and emotions with reference to learning in 3D immersive virtual environment.
2. **Task Class3D**. Again, an open discussion was performed at AMU class where the students could share their experiences from interacting with the 3D virtual environment. Additionally, the students filled an anonymous questionnaire where they compared a 3D virtual class with their regular intramural language classes in the physical world at AMU.
3. **Task ExploreSL**. Each team was to prepare a multimedia presentation (PowerPoint or others) which would present the educationally functional SL spot of their choice. The presentation was supposed to include: the name of the spot together with the SLURL, a few pictures of the spot taken inworld, a short description of the spot, a short report of why they considered the spot to be functional in foreign language learning. Each team showed their presentation to the whole group and commented on it. The presentations were followed by a discussion among the group. Note: all the PPT files are made available from the AMU computer server to all the 60 student participants. Additionally, the students filled an anonymous questionnaire where they gave their opinions and attitudes towards 3D immersive environments in language learning and generally in education.

3.3 Results

The data collected underwent statistical analysis. So far, the results from the November-January part have been analyzed (N=60). The initial analysis indicates that the educational functionality of the virtual world of Second Life has been confirmed in most variables again. As the Mid-Stage project is still running, only rough conclusions can be drawn:

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- students confirm the attractiveness of the immersive virtual environment for foreign language learning,
- many students were rather passive during classes at Virtlantis and Cypris Chat. They admitted that it was a totally new experience for them,
- students interacted both with the teacher, with each other, and with the virtual objects in Second Life during Class3D,
- students were very active and had fun in the ExploreSL task. They enjoyed teamwork type of learning.
- students had positive attitudes toward the virtual world as a learning environment (anonymous survey).
- majority of students declare they may make use of Second Life for educational purposes (not only language learning) in the future (anonymous survey; the students will be surveyed again a few months after the project is closed, and the results will be compared to those of today).

This year's positive results gathered so far lay out a good perspective for future research undertakings. The data to be collected in the spring semester 2017 will undergo statistical analysis in April (after the first half) and in June/July (after the second half of the semester). As the total will be about 160 participants, a deeper analysis may be provided than that of today.

4 Next year's Project (Main Stage Two)

Second Life proved to be educationally functional in foreign language learning in both editions of the project: in 2011-12 and currently in 2016-17. Main research Project Stage 2 is initially planned for the next academic year 2017-2108. It shall be performed on the students of AMU again, but it would possibly engage students of another university in Poland, in Europe or worldwide[5]. The project shall last full semester and shall be organized in two independent parts for the first and the second halves of the semester.

As far as methodology is concerned, the future study would probably include the following areas and consecutive hypotheses (selection):

- cultural-cognitional functionality: students will have higher culture gain in 3D than in 2D learning environments;
- effective functionality: students will have higher language gain in 3D than in 2D learning environments;
- students will have higher emotional impressions from 3D environments (and from learning there) than from 2D learning environments;
- students will assess positively the 3D virtual world as a socio-interactive environment in language learning tasks.

[5] It might be one of the US universities that AMU has already had a collaboration project with, which involved Polish and American students in online activities [Topol, 2008].

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The study shall involve different student activities (selection[6]):

- obligatory language lessons participation,
- discussion panels inworld with students of the other university involved in the project,
- individual tasks to be performed inworld,
- teamwork and sharing responsibilities while performing group activities in the virtual world,
- exploring the virtual world in international teams (plus sharing the results),
- panel discussions gathering all the participating members (both faculty and students) on the 'real' or 'hypothetical' added value(s) of 3D immersive virtual environments.

There will be two new elements added to the methodology and performed by the author:

- Virtlantis and Cypris Chat (or other SIMs that offer language classes free of charge[7]) – also the teachers will be surveyed or interviewed, and asked to share opinions from their perspective on students' learning in the virtual world;
- other places in SL where the students will be sent to perform their tasks and activities – also the owners or administrators of those SIMs will be interviewed prior to the students tasks in order to obtain a more detailed description of the spot, e.g. by guided tours. That might help the teacher and researcher prepare the activities better[8].

The study is planned initially for the Fall semester of the academic year to come, however, it might be extended to the whole academic year (including the Spring semester). The decisions will depend on consultations between the author (Adam Mickiewicz University) and other potential parties engaged in the project.

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[6] Based on the results of consultations with the other university partners.

[7] A general principle of all the editions of the project was and is that the students do not bear any costs in Second Life. Therefore, commercial language schools in SL have not been taken into consideration.

[8] Based on the author's previous experience in exploring SL for glottodidactic purposes, and the study of Rodrigues, et.al., 2015].

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Assessment *for* Learning and Gamification: Can Two Walk Together, Except They be Agreed?

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Abstract. The abstract Although studies indicate the potential of Assessment *for* Learning (AfL) to promote academic achievement, reality shows that in various education systems this potential is not realized. Some attribute the reasons to lack of motivation on the part of learners to invest in deep learning, or to their deficient learning skills. We offer to deal with these barriers by focusing on fostering student motivation and agency. For this end, we propose a virtual learning environment that incorporates principles of AfL and gamification, which combined with the physical learning environment in classroom create two interrelated activity systems that feed each other in a co- evolutionary process. In the first part of the paper we define learner agency and ways to foster it, we continue by defining AfL and gamification and their principles, then compare characteristics of students in classrooms where AfL is successfully practiced with characteristics of successful players in digital group- games. In the second part, we explain how gamification can upgrade AfL, and display features of the proposed learning environment. Finally, we discuss attributes of educational contexts that are contusive for successful implementation of the proposed learning environment.

Keywords: Assessment for Learning, Gamification, Agency

1 Introduction

Research in assessment for learning (AfL) during the past two decades has pointed to the potential of AfL to promote deep learning and increased academic achievement (Black & Wiliam, 1996). However, the reality in various educational systems indicates that AfL has failed to fulfill its potential (Klenowski, 2009). Some of the explanations offered are the lack of students' motivation to invest in deep learning and deficiencies in their learning skills (James et al., 2007). The current paper proposes to deal with such barriers by fostering students' motivation and agency through a virtual learning environment that integrates AfL and gamification principles.

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1.1 Learner agency

Agency is defined as "the capacity and propensity to take purposeful initiative—the opposite of helplessness" (Ferguson, Phillips, Rowley & Friedlander, 2015, p.1). According to Bandura to be an agent is to intentionally make things happen by one's actions (Bandura, 2001). As a psychological construct, agency embodies belief systems, capabilities of self-regulation, and a variety of other structures and functions, through which personal influence is actualized (Bandura, 2001). Self-efficacy (the faith in one's ability to succeed in achieving one's goals) is a fundamental structure of agency according to Bandura (1997). Among other factors associated with Agency are Conception of intelligence as a growing rather than a fixed entity (Dweck, 2006), consciousness, mastery orientation, and future orientation, (Ferguson et al., 2015).

From a sociological perspective, agency is perceived as a socially mediated capacity to act. Such function is constructed in social interactions using mediating structures, which lead to dynamic and mutual relations between the two, whereby the structures mediate the agency that a person takes, and in turn, the person's ability to take agency mediates the structures. Consequently, contradictions that might occur between the two in their reciprocal relations could lead to their coevolution (Siry, Wilmes & Haus, 2016).

Educators worldwide attribute great importance to the development of learner agency since it is consistent with educational goals for the 21st century that are aimed to promote competencies for successful functioning in the workplace, such as critical thinking, creativity, collaboration, and communication (Binkley, 2012). Such skills are also critical for self-regulated lifelong learning that is essential in light of the rapid pace of knowledge renewal (Pintrich, 1995).

The justification for promoting learner agency has been advanced recently by Peter Renshaw (2016), who argues that agency is an aspect of the human functioning, the focus should be on its quality (what is a good agency) rather than on its quantity (more or less agentic). Moreover, since what could be considered good agency is culture related, Renshaw suggests three perspectives for justifying agency promotion: Epistemological perspective (developing competence for knowledge construction), personal perspective (personal empowerment), and social perspective (socialization to norms and expectations of a given culture.)

Recommendations to foster student agency (both, individual and collective) through AfL come from AfL researchers and practitioners engaged in teacher training and professional development (Earl & Katz, 2006; Willis & Cowie, 2014). In this vein, AfL was incorporated in the Learning How to Learn (LHTL) – in Classrooms, Schools and Networks Project that took place in England at the beginning of Millennium (James et al., 2007).

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1.2 AfL: Definition and principles

AfL, as defined by the Assessment Reform Group (ARG, 2002), is ‘‘the process of seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there’’. More recent definition states that ‘‘AfL is part of everyday practice by students, teachers, and peers that seek, reflects upon and responds to information from dialogue, demonstration and observation in ways that enhance ongoing learning (AFL, 2009). Implied in these definitions are the following principles and attributes of AfL: the goal of the assessment to advance learning; its social nature that rests heavily on dialogue between the assessor (teacher or peer/s) and the learner; its dynamic nature and continuous enactment; the utilization of a variety of tools and strategies to make learning explicit, and the interpretive and integrative manner by which inferences are derived. As for the learners, the definitions point to their active role in the assessment; they participate in formulating its objectives, in developing rubrics, as well as perform the self-and-peer assessment.

Contemporary writings about assessment conceptualize it as inquiry (Delandshere, 2002); indeed, an optimal AfL cycle corresponds to an inquiry cycle. It consists of six phases: planning (setting goals, defining objectives); designing tools to elicit learner’s understanding; evidence collection (including provision of accommodations when needed); interpretation (estimating the gaps between intended and obtained outcomes and generating feedback to the learners and the teacher); utilization (taking measures, where needed, to close the gaps), and evaluation (assessing the effectiveness of those measures in closing the gaps.)

1.3 The potential of AfL to promote learner agency

AfL is grounded in the 'learning center' paradigm, according to which instruction is aimed to help students construct their own knowledge; the teacher becomes the mediator who provides her students with an appropriate learning environment and acts as a supervisor of the construction site (Biggs, 1999).

From a socio-cognitive perspective, AfL is consistent with conceptions of the educational process as a socio-cultural dialogue, and of learning as a collaborative construction of knowledge (Brown, Collins, & Duguid, 1989; Lave and Wenger, 1991). It is responsive to the interplay between individual and collective knowledge construction whereby they feed each other regularly. Hence the claim that “AfL can then be conceptualized as more than a series of techniques or strategies; as part of a dialectical and cultural process of increasing understanding and control of the learning process by the learner – that is, exercising agency” (Willis & Cowie, 2014, p.25). However, as was mentioned above, this conceptualization is not always reflected in educational practice, seemingly due to students’ lack of motivation to invest efforts in performing “school-type tasks,” which they consider as irrelevant and disconnected to their experiences in “real life.” They are eager to invest efforts in learning in other contexts, for example, to

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improve their skills in extreme sports, in digital games, etc. Hence the need to develop innovative pedagogies and learning environments suitable for the "digital natives." Our proposal to upgrade AfL based on gamification principles is thus an attempt in this direction.

1.4 Gamification: Definitions and principles

The growing interest in integrating gamification into the formal teaching system stems from the need to create experiences that encourage students' commitment to and engagement in the learning process and increase their motivation for pursuing meaningful learning.

Gamification is defined as "The use of game design elements in non-game contexts." (Deterding et al., 2011, p9). The central principle underlying the theoretical foundation of "gaming for learning" is that we were born to play, thus infusing fun is the most efficient way to motivate action and to change habits and behaviors for the better. Koster (2013), in his book "The theory of pleasure to design games", argues that the increasing motivation and interest in games stem from the tasks and the challenges that are built-in into the ground rules. The players face increasingly harder challenges thus they have to exhibit understanding and control to advance to higher stages and win the game. Such struggling involves fun. Hence fun is synonymous with learning.

The Gameful design of learning environments aim is to increase motivation and promote learners' agency. According to Paul Gee (2014), digital games are complex semiotic systems. They are, by definition, environments where uncertainty prevails.

Dispositions and competencies through	
AfL lens	**Gamification lens**
Attribute value to learning	Love to learn new things and improve their skills
Eager to know, curious, inquisitive	Curious; Always see the challenge, as in digital games
Enjoy challenging learning-tasks	Goal oriented and highly motivated to succeed
Exhibit self-efficacy for learning	Persisting, not give up when faced with obstacles and difficulties
Have skills to adaptive to changing conditions	
Critical thinkers	Optimistic about their ability as a group to overcome and succeed
Reflective and Creative	Creative and accustomed to thinking outside the box to solve challenging problems
Switch roles and characters as needed	

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Set their learning objectives and monitor their performance towards achieving them	Are used to learn by watching others and themselves in replays
Exhibit leadership and management skills when required	
Recognize the importance of formative assessment, crave for feedback	
Know how to give constructive feedback	Eager and accustomed to receiving feedback on their actions
Not afraid to make mistakes, realizes that understanding grows out of mistakes	Consider failure as an integral part of the learning process Willing to sacrifice for others
Exhibit initiative and resourcefulness	Take risks and step out of their comfort zone
Feel responsibility for their own learning	Enact systemic thinking in a complex environment
Diligent, hardworking	Are accustomed to learning under uncertainty

Table 1. Dispositions and competencies of learners in classrooms where AfL has been implemented successfully and of players in challenging games

A skilled gamer succeeds when he acquire "ownership" of the game space, and it's underlying roles. Moreover, gamers can be anything they like, including directors and heroes in their journey. Compared to learning in the classroom, the degree of autonomy granted to players is higher. The challenges facing all gamers are tailored to their abilities and skill levels, thus enhancing their self- efficacy and their competencies. Contrary to the myth, most of the time gamers play together with other players, thereby increasing their relatedness and social skills. Such characteristics elevate the internal motivation of players and enhance their agentic capacity (Gazit, in preparation).

1.5 Dispositions and competencies that reflect optimal AfL implantation and challenging gamification

Studies of children, adolescents, and adults who play digital games have shown that those who play regularly, develop a playful approach that is characterized by fundamental beliefs, distinct patterns of action and competencies (Gazit, in preparation).

Table 1 presents dispositions and competencies of students in classrooms where AfL has been implemented successfully (Birenbaum, 2014, 2016) (marked as AfL lens) vis-à-vis those found in ethnographic studies of gamers in online digital games (marked as Gaming lens) (Gazit, 2009; Lavee & Gazit2012; McGonigal, 2011).

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As shown in Table 1, similar attributes are visible through AfL and gamification lenses regarding self-regulation and self-efficacy – two main components of agency, as noted above. Theoretically, the conceptualization of the three constructs (AfL, gamification, and agency) is based on the socio-cognitive theory (Bandura, 1986) and the Self-Determination theory (Ryan & Deci, 2000), which are rooted in the perception of humans as proactive, having cognitive and metacognitive abilities, capable of self-regulation and reflection rather than as creatures who react, are being activated by environmental forces or driven by internal impulses. According to these theories, the combination of autonomy, socialization, and self- efficacy enhance intrinsic motivation. It is thus not surprising to see similar attributes through Afl and gamification lenses.

2 The Proposed Learning Enviroment

In this section, we discuss how gamification can upgrade AfL; present attributes of a virtual learning environment aimed at fostering learner agency, and describe the activities that can take place in such environment.

2.1 How can gamification upgrade AfL?

In spite of the common theoretical foundation that AfL and gamification share, in practice, there is a difference between how students learn in school and how they learn in games or other challenging activities in the "real world", in which they strive to excel. Gamers in MMOGs (Massive Online Games) are enthusiastically learning by themselves, or in collaboration with their peers, by mindfully utilizing the feedback provided to them.

Likewise, when engaged in extreme sports, they are eager to receive feedback, analyze their mistakes, learn strategies by observing models (champions) in action, try the strategies and compare their performance to that of the models. In general, they are characterized by embracing change and being eager to learn to improve their performance (Brown, 2011). Conversely, as school students, many of them are not keen to learn even when feedback on their performance is available to them, seemingly because in traditional teaching they are submissive subject to obscure teaching and assessment dictates, and their learning experience as a whole is not in alignment with their experiences in the "real world". Indeed, the current generation, known as Generation Y, or Gamification Generation (Gazit, in preparation), is exposed in many schools to teaching methods that are based on epistemological beliefs and perceptions that were proper for achieving the educational goals of the past but are not suitable for achieving those of the 21st century. It is therefore not surprising that many teachers fail to engage students in their lessons and in the learning tasks, which are seen by students as "burdensome necessity". Consequently, the more motivated students orient themselves towards achievement goals rather than learning goals, especially nowadays when such orientation seems in line with education policies that adhere to external test-based accountability, despite wide criticism regarding its collateral damage (Berliner, 2011). Moreover, it is difficult to update teaching and assessment methods so that they competently

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utilize digital technologies due to the reluctance of many teachers to apply these technologies, thus leading to preservation of "archaic instruction," as perceived by students. As a result, the generation gap grows between teachers ("digital immigrants") and students ("digital natives"), making the schooling experience appear less and less attractive and relevant to the students.

Consequently, we propose to deal with those barriers by harnessing gamification to upgrade the teaching, learning and assessment experience in school so that it appeals to students and foster their agency. Specifically, we propose a virtual gameful learning environment, which combined with the physical learning environment in the classroom will offer a bi-level blended learning space. The rationale underlying the development of the virtual environment argues that if the goal is to foster learner agency, teaching cannot be a process that is planned and executed solely by the teacher while the students are submissive subjects to its dictates. It should rather be a process that students understand its language and tools and are partners in planning, executing and monitoring it together with the teacher. In other words, we argue that for students to be involved in learning, take responsibility, exhibit initiative and desire to know they need to participate not only in the assessment but also in the instruction process.

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2.2 Characteristics of a gameful learning environment geared to foster learner agency

The goals of the virtual gameful learning environment are addressed from three different perspectives: Epistemological, Subjective, and Social, as advanced by Peter Renshaw (as described above) to justify fostering learner agency.

From an epistemological standpoint, the aim is to evoke deep learning due to student participation in the instruction and assessment, adapting them to the media utilization of "digital natives."

From a subjective perspective, the goal is to empower students so that they become self-efficacious regarding their ability to self-regulate their learning, to co-regulate learning, and to socially share regulation of their collaborative learning.

From the social perspective, the goal is socialization to norms and skills required for proper functioning in the 21st century.

The proposed virtual environment, labeled AfL Island, is designed to offer students an activity space, which they would be responsible for its design and management, so as to encourage them to be active participants in the instruction, learning, and assessment processes.

This virtual activity space, which can be accessed 7/24, contains learning and teaching resources as well as virtual facilities, devices, and tool for learning-related and leisure activities. Students will design, build and shape the space according to their preferences (as in a Minecraft environment) and will operate and maintain it. The general guidelines and targets for the activities that will take place in the AfL Island will be formulated by the students under the guidance of the teacher.

The virtual activity space can be utilized for knowledge management, i.e., documenting the collective knowledge constructed during classroom discussion (knowledge maps, lesson summaries, exemplary performances, etc.); managing inventories of strategies, tools, and applications for instruction and assessment, of standards and rubrics; assembling a library of relevant information resources.

Moreover, the virtual space can be used for the construction of models and illustrations for instructional purposes, and for the development of learning games and group games as well as for cooperative learning interactions such as peer assessment, synchronous and asynchronous discussions and more. It is also possible to conduct in this space experiments (in a virtual lab) and hold exhibitions and conferences in which learning outcomes can be presented.

The activity that takes place in the virtual space offers opportunities to the student to take responsibility, develop "expertise," assist and guide their peers, work in teams, solve authentic problems and cope with challenges. As such, the activity is expected to promote deep learning, self-regulation, co-regulation and socially shared regulation,

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increase motivation for excellence, and empower those students who usually do not participate in classroom discourse ("transparent students"), as well as foster self- and collective efficacy, and a sense of cohesion. Moreover, it can also expand students' personal identities due to the experience they gain from taking on roles as performed in the workplace of the 21st century, which require competencies, most of which are unrealized by students as part of their regular school work. As such, the activity that takes place in the AfL Island has the potential to contribute to the advancement of learner motivation and agency.

2.3 Activities in the AfL Island

The students start designing and constructing the sites for the various activities that are about to take place on the island, including buildings (centers), infrastructure and landscape, based on the specified purpose of the isle. The construction process is led by the students who are experienced with, and enthusiastic about using 3D creation softwares such as Minecraft.

Once the island is created, the activity centers are put into action. Such centers can include:

- Information and resource centers, to which students can turn for advice, to receive training, and to share information. The directors of such centers are elected by their peers and represented by avatars. Their responsibilities include: locating, collecting, organizing, and cataloging information resources and learning tools; disseminating information and tools; providing consultation services to fellow students and to teachers; initiating educational activities and events such as exhibitions and conferences (at the classroom, the school, and the community levels), which are to be held at the center or in collaboration with other centers.
- Learning activity centers, to which students turn to work on assignments and develop concrete materials using specialized software.
- Leisure activity centers, to which students come to play, practice, and learn together extracurricular subjects.
- The island administration which consists of the cyber center, and development and communication centers. The students who run this center hub manage the virtual environment and the internal and external communication.
- Knowledge dissemination centers which include a conference center, a museum, and several galleries in which learning products are displayed or presented and discussed.

The performance of each center is assessed based on an automatic log produced by the system, so that each center team is motivated to excel, and each team member feels responsible for the success of the team.

The scoring and rewards system (e.g., medals, awards, status scores for contribution to knowledge construction, etc.) is based on a set of criteria that has been determined in a

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joint discussion between the teacher and students and is agreed upon by all participants. Scoring reports are regularly available and are transparent to all participants.

Every semester, the team of each center is required to submit an evaluation report regarding the center's activities based on the data produced by the automated system, in which they reflect on the center's performance, i.e., to which extent they have reached their objectives and in case of a discrepancy, suggest how to close it and improve the performance next semester.

The activity in the AfL island follows procedures, regulations, norms and ethics rules by those in effect at the school.

From an Activity Theory framework (Engeström, 2001), the two learning environments – the virtual (AfL Island) and the physical (classroom) can be seen as two activity systems, where mediation between the subject (learner) and the object (learning goal) is accomplished by tools, including intervention by the teacher and fellow students. The two systems differ in the division of labor between the teacher and the students and among the students. While in the classroom the teacher dominates the interactions, in the AfL Island the students dominate and use a larger variety of tools than in the classroom. The two activity systems are coordinated and interrelated as each one feeds the other continuously, which leads to their co-evolution and to the creation of a "third space" (Engeström, 2001), in which personal learning evolves.

3 Conclusion

Contextual conditions that can promote successful implementation of the proposed learning environment. A classroom that would appreciate activities of the kind occasioned by the AfL Island is characterized by a climate of growth, relationships of trust and mutual respect among students and with the teacher, the students like the teacher and feel that she cares about them. Typical of such classroom are norms of mutual support, transparency, openness and legitimacy of errors; The students feel confident to try, to dare, to initiate and set challenges and believe in their ability to meet them. They are experienced in teamwork and peer teaching and participate in self- and peer assessment.

The teacher is caring, thinks outside the box, sees herself as an educator, not as knowledge imparting agent; it is important to her to cultivate values, to foster critical thinking and creativity, as well as social competencies, to empower her students and enhance their self- efficacy. Professionally, the teacher feels she is supported by "critical friends" in the school- based learning community, which is a cohesive one and maintains cooperative learning.

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The team members are motivated to improve the learning ability of all students and nurture their agency, and they believe in their collective capacity to meet these challenges, and feel pride. They exhibit constructivist conceptions of instruction, learning, and assessment, and attach importance to cultivating students' interest in the discipline they teach. It is a team that thinks outside the box, is enthusiastic and open to new experiences, exhibits an inquisitive disposition, practices professional accountability and internal regulation.

The team members feel that they receive full backing, support, and assistance from the school management that sets a high priority on fostering agency both among staff and students.

Schools with such properties of organizational culture seem conducive for successful implementation of AfL Island and mindful integration of the virtual and physical activity systems. The Researchers

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GAMES AND GAMIFICATION IN THE PEDADOGY DEGREE: an alternative to the Distance Education models

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Abstract. The issue that gives rise to this article is to understand the potential of games and gamification for the creation of new designs in the Distance Education (DE) and it is found in the research "GAMING IN HYBRID AND MULTIMODAL COEXISTENCE SPACES context: an Experience in Higher Education", sponsored by CNPq, CAPES and FAPERGS. The objective was to develop pedagogical alternatives to the DE models, so that methodologies and practice are meaningful to the current learning subjects when considering their culture, evidenced in the way they learn in different contexts, in order to provide a more effective engagement in the teaching and learning processes. The research is exploratory and qualitative, inspired by the cartographic intervention-research method. It makes use of the participant observation, logbook and records in texts, audios, pictures and digital video. The data are interpreted from the theoretical framework. As a conclusion, the results indicate that both the process of thinking and creating a game, as the mechanical and dynamic appropriation present in different games in order to develop the teaching and learning processes, constituted themselves as an effective pedagogical alternative in creating new designs in Distance Education (DE).These, when associated with the methodology of learning projects based on problems and cartographic method of intervention research, as an innovative pedagogical practice, have the potential to expand the traditional DE models from the perspective of building hybrid, multimodal and pervasive learning spaces. These spaces were configured as Living Spaces in a process of co-creation from the critical reading of the daily life basic education, where some problems were identified, to which the games and gamification can contribute to the changes. There was a greater engagement of the learning and reframing subjects of the experience experienced in the initial formation for the Elementary Education. The discussion about the need for reconfiguration arises from the pedagogical practices and curricula, as well as how to organize it in time and space from the daily life issues, enabling the construction of learning pathways in order to contribute to an emancipatory and citizen education.

adfa, p. 1, 2011.

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Keywords: Distance Education; Higher Education; Basic Education; Games and Gamification; Hybridism, Multimodality and Pervasiveness.

1 CONTEXT

We live in a world marked by hybridism, multimodality, pervasiveness and ubiquity. Hybridism manifests itself in relation to spaces (geographical and digital), presence (physical and digital), technologies (analog and digital) and culture (analog, digital, gamer, maker and others). Multimodality emerges in the coexistence of physical and online presence modalities while pervasiveness and ubiquity enhance the situated learning, providing the subject with "sensitive" information to his/her profile, needs, environment and other elements of the learning context at any time and place. In this environment, location technologies (GPS and navigation and location systems), identification (RFID tags, QR Code and markers) and sensors, among others, may be present in applications, games and gamified processes. It is in this context that the current learning subjects develop themselves, constituting own culture in congruence with this historical-social space-time.

But what has changed? To answer this question, it is necessary to make an analysis from the current daily life, in which children and adolescents develop themselves (considering the way they express themselves, shown below) in the relationship with the daily life that constitutes them and in which they build concepts (pre-digital).

A 5-year-old child says, "Mom, I beat the book", when she finished reading her first physical book (paper). "Look!!! Obsidian to build the portals in Minecraft[1]", says another 10-year-old child while exploring a museum of science and technology. Beat, in a pre-digital context, can mean physical impact or aggression and, obsidian, only a volcanic rock. However, for many of the children of the current generation, beat acquires first the meaning of completing a game and obsidian is known as the element that allows the construction of portals in the Minecraft game. Thus, the first meaning that these children have for these and other concepts result from the interaction in the digital world, which will later be used to mean situations in the analog world.

"Can I go to the computer?", "I'm in Minecraft building a world", "Let's enter into the Unturned?", "Come and meet my family, I'm a cook now but I'm also a gamer and an astronaut" (children's lines when they are playing The Sims 4), and also "Let's go hunting Pokémon?", are expressions found in children and adolescents' daily lives, which allows us to understand that the digital technologies also represent a place to go, where one is and where something is done. These subjects, by "being", "entering", "being able to act" and "interacting" with different Digital Technologies (DT) from a very early age, think with and from the digital, which collaborates to attribute meanings to the analog world from their actions and interactions with and in the digital world. Such actions/interactions constitute perceptions and experiences that become hypotheses used to understand the hybrid world in which they live and coexist.

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[1] Minecraft is a game created in 2009 by Markus "Notch" Persson; it is a video game sandbox type, independent and open world kind that allows the construction of different worlds from blocks (cubes). It has two basic modes: survival and creative.

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Papert [15] stated that the current generation, being used since very early to use the computer at home and at school, felt more comfortable with different DT and became technologically more fluent in their use than most adults. The presence of these technologies could affect values and also cause a gap between the generations [15] with consequences that need to be understood in order to create necessary bridges between the two generations.

Linked to this concern, Schlemmer and Lopes [22] call attention to the cultural aspect when considering that being part of a new culture does not simply mean knowing how to use DT (cognition), but also "why" use them (meaning). It is a question of understanding what these changes may mean for the education context. This refers to both how they are being considered in the political-pedagogical projects and in the degrees' curricular organization at different educational levels, as well as with respect to how teachers are considering these changes in the teaching and learning processes, as well as which methodologies and practices can be used in the implementation of a competent pedagogical mediation in this context. And, fundamentally, understand how universities are considering these changes by training teachers in their undergraduate, masters and doctorate degrees in education. What are the surveys showing? In addition, it is particularly important to understand how these changes have contributed to rethinking the university itself and also the research.

However, when we look at different educational institutions, especially at the higher level, few effective changes are identified, since the ones that exist, for the most part, are reduced to the presence of DT (many of them already considered outdated in the view of current learning subjects) in the teaching and learning processes, however, without these processes being rethought and transformed in a significant way. They continue to replicate teaching models, methodologies and pedagogical practices that are clearly dissonant with the context previously presented. This situation gets worse when these same models/methodologies/practices are used into the DE.

Distance Education (DE) is the modality of teaching in which teachers and students are physically distant during all or part of the educational process time [13]. This educational modality encourages learning throughout life (lifelong learning) and allows updating and professional development for those unable to attend formal educational spaces due physical, geographical, financial and other limitations. The physical and temporal separation between teachers and students of the DE modality presents self-characteristics that require specific knowledge by the part of who plans, develops and evaluates the formations developed in this modality.

Although the term DE is in evidence in the recent years, the modality is not new: mail, radio and TV have already been used to teach in the distance, although the direction was unidirectional without favoring the effective interaction. However, the DE, when linked to DT, can expand the possibilities of training and democratize the access to the information, which can effectively be verified in the growth scenario of the DE modality [6], in which this study is inserted. However, there are criticisms about the currently existing models: focused on the Virtual Learning Environments technology, in the mass content, in education/task, lack of clarity between information and knowledge and the need to overcome the hierarchical model [18].

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The criticisms arise precisely because the DT progress can replace the distribution logic (transmission) by the communication logic (interaction). At the confluence of DT, the emission pole release (which promotes the autonomy and authorship of the subjects) and the generalized connection, it is the potential for the practices and institutions reconfiguration [10]. Considering that the social context cannot be understood or represented without its technological tools [3], the contemporary DT and the Internet have enabled the emergence of online education, a cyberculture phenomenon characterized as a "set of teaching-learning actions mediated by digital interfaces that enhance interactive and hypertextual communication practices" [18, p. 5663].

In online education, digital technologies, especially Web 2.0, characterized by ease of authoring, publishing and discussion [24], provide interaction levels that exceed temporal and spatial limits imposed by physical classroom education, enabling the execution of educational projects in hybrid contexts, multimodal and pervasive that permeate the current historical-social space-time. But care should be taken because a course project is not based only on the set of technologies and information, but on learning effectively constructed, since "[...] communication is sharing sense" [11]. In addition to the content transmission, there must be the knowledge building through effective interaction between the actors in the educational process.

The challenge is to follow the technological transformations, as well as to understand how they are modifying the way of living, co-exist and learning of the current learning subjects, in order to have elements that allow the construction of different designs, methodologies and practices consistent with the changes that are taking place, surpassing, as well as the standardization and, why not say pasteurization, currently found in the DE, which is limited to follow certain models. A nowadays project design must overcome the dichotomy between physical presence modalities and distance education, considering mainly the culture of the learning subjects, who were already born immersed in a world marked by hybridism, multimodality, pervasiveness and ubiquity` context. Thus, justification, problem and objectives are now presented.

2 JUSTIFICATION, PROBLEM AND OBJECTIVES

The justification for this research arises from: a) anxiety with the daily teaching in the Higher Education degree (physical face-to-face, DE and online modalities), especially with regard to educational design; b) perception of the distance between the pedagogical practices developed in the context of higher education and how these subjects (students of higher education) learn (considering the ways in which they interact), in relation to the pedagogical practices developed in basic education and how children learn (considering the ways in which they interact) and; c) need to understand the potential of games/gamification (in the perspective of the "Games for Change movement") in a hybrid, multimodality, pervasiveness and ubiquity context, considering BYOD[2] and Flipped Classroom propositions, as enablers of knowledge experiences.

[2] Bring Your Own Device (BYOD) is a trend that emerges from the mobile world and in the Education filed, proposes to give freedom to students in order to bring and use their own mobile devices in the educational context.

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From this anxiety, from this perception and from the identification of this need is that the research problem originates, which consists of understanding the potential of games and gamification for the creation of new designs in Distance Education (DE).

The objective was to develop pedagogical alternatives to DE models, so that methodologies and practices are meaningful to the current learning subjects and to consider their culture, evidenced in the way that they learn in different contexts in order to provide an engagement more effective in teaching and learning processes. They constitute themselves even as objectives:

- using games and the concept of gamification (in the perspective of the "Games for Change" movement) in a context of hybridism, multimodality, pervasiveness and ubiquity, considering the propositions of BYOD and Flipped Classroom as facilitators of knowledge experiences;
- understand this proposition's potential to provide the articulation between the initial formation and the pedagogical practice developed in Basic Education.

The desire was that the subjects felt incited, provoked, curious, engaged in learning, and that this could happen in a fun way. Thus, in a growth scenario of the DE mode [1], it becomes imperative the interest in understanding, problematizing and presenting alternatives to the current models. The confluence of subjects immersed in hybrid and multimodal coexistence spaces with the search for meaning in their learning pathways, which can occur in any context and in multiple scenarios, justify investigating/creating pedagogical alternatives that make it possible to overcome the current DE models. In this sense, it is understood that both games and gamification can contribute significantly to think about the creation of new educational designs, in this case, more specifically, related to DE. The research methodology is following presented.

3 METHODOLOGY

The research is exploratory and descriptive, with a quantitative and qualitative approach, inspired by the cartographic intervention research method [8, 9, 16, 17] and it makes use of the participant observation, logbook and records in text, audio, photography and digital videos` format left as traces in different interaction spaces.

In the context of researches which are developed at GPe-dU UNISINOS/CNPq, we have explored research methodologies and intervention that can inspire new practices that are aligned to the need to understand the learning phenomenon in all its complexity. Thus, the research and intervention cartographic method began to be studied. Cartography is a method that aims to follow a process and not represent an object [8]. In general terms, it is always a question of investigating a production process without seeking to establish a linear path to an end. "Cartography seeks to ensure the accuracy of the method without giving up the unpredictability of the knowledge production process, which is a positive requirement of the ad hoc investigation process" [8, p. 19]. Its construction on a case-by-case basis does not prevent the attempt to establish some clues that are intended to describe, discuss and, above all, to collect the cartographer's experience. Cartographic attention is defined as concentrated and open,

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characterized by four varieties: tracking, touch, landing and attentive recognition. Because it is intervention research, the analysis occurs in the process, that is, in the cartographic movement, which makes it possible to carry out the intervention.

The data generated in cartography were organized, categorized and stored in the dynamic database using NVivo. The data interpretation was based on the theoretical framework that underlies the research, which made it possible to re-signify the learning spaces as well as the educational designs in a learning context that currently consists of hybrid, multimodal, pervasive and ubiquitous spaces of coexistence.

Following is the empiria, as well as the developed creative process.

4 EMPIRIA

The empirical field that composes the research and that gives rise to this article refers to the Academic Activity Teaching and Learning in the Digital World (AA-EAMD), linked to the Bachelor's Degree in Education from Sinos Valley University (Universidade do Vale do Rio dos Sinos) – UNISINOS. AA-EAMD is an obligatory academic activity, offered in the online modality, with a 60-hour class course (six face-to-face meetings and 14 online meetings). The physical face-to-face meetings take place in the classroom/computer lab and in different geographical spaces in the University. The online meetings take place through the Moodle Virtual Learning Environment, social media, digital notebooks, metaverses - 3D Virtual Digital Worlds, simulators, games, instant communicators, web conferencing software, Google tools, and others.

AA-EAMD aims to create learning and digital emancipation spaces capable of fostering the development of theoretical and methodological approach and technological knowledge that promote the integration of different digital technologies in the construction of knowledge. It also seeks to reflect about the use of these technologies for human and social development within the Early Childhood Education framework, early years and Teenagers and Adults Education.

The Empiria refers to the first and second semesters of the years 2014, 2015 and 2016, totaling 166 students, with ages between 17 and 60 years, predominantly women. In this process over the three years in different semesters/year, four female students of the Doctorate in Education and a female student of the Bachelor's Degree in Pedagogy, which is a monitor at AA, participated in this process.

It was in this context, and considering the justification, problem and objectives previously explained, that originated the methodological design of AA-EAMD, which was inspired by the cartographic method of intervention research developed by [8, 9, 16, 17] while an interventionist pedagogical practice. This methodological design consisted in experiment the cartographic movements associated with the learning projects methodology based on problems adapted to the Higher Education[3], in the connection with the gamification concepts, flipped classroom and BYOD, within the construction perspective of a hybrid and multimodal coexistence space. In this case,

3 SCHLEMMER, 2001; TREIN & SCHLEMMER, 2009.

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the clue and tracing metaphor[4] served as inspiration to design the missions' composition and monitor the progression in the gamification.

Tracking (field scans), touch (triggers the selection's process), landing (stop-zoom) and attentive recognition (perception of the missions overall context) were considered achievements[5], at the same time that they could be understood as skills for their own gameplay and sociability. The evaluation took place while monitoring the learning process of each subject when carrying out his/her course, allowing conquering powers - XP or EXP (knowledge/experience).

Based on [5, 7, 25, 26], Schlemmer [20, 21] addresses the gamification in education considering that gamification, when related to education, consists basically in using the way of thinking, styles and game strategies as well as elements of games design, such as mechanical and dynamic (M&D), the educational context as a means of providing agency, dumping, transformation [14] and fun [1, 2]. In this way, gamification involves subjects in the teaching and learning processes that encompass discovery, invention and problem solving. Gamification is concerned, then, to analyze the elements that are present in the game design and make it fun, adapting them to situations that normally are not considered games, thereby creating a game layer on a situation, process or product, instead of being, originally a game.

The concept of gamification, although created in 2002 by Nick Pelling, expands in 2008 with the growth of the gaming industry and spreads from 2010 by the wide use in diverse contexts. Linked to gamification, the perspective is explicit, for example, by "Games for Change" movement, which aims using games for social development. According to McGonigal [12], people prefer cooperative games. In games, the most of people do not want to compete, but rather work with their friends to achieve a common goal, being together. If the players are willing to perform challenges involving obstacles, often unnecessary, the games have the ability to mobilize. Thus, they can be used as instrument for social transformation. In this experience, this transformation is linked to the educational institutions daily life (Higher/Basic Education).

In education field, gamification can be considered from at least two perspectives: while persuasion - stimulating competition and having a scoring system, reward, awards, etc., which from education's point of view, reinforces an empiricist and epistemological perspective and; while collaborative construction and while cooperation and empowerment - instigated by challenges, missions, discoveries, group empowerment, which leads to interactional-constructivist-systemic epistemological perspective (inspired, for example, by elements present in Massively Multiplayer Online Role Play Games – MMORPG) [20].

Thus, at the origin of a process gamification is the understanding of the problem and the context, which involves understanding the subjects' culture, environment, subjects' objectives and the institution. From these elements, it is possible to think about the M&D's set, which will be used to develop the gamification, which will

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4 In this case online clues - using QR Codes and live tracks - experts, according to the problematic addressed by each Clan.

5 In the world games language, achievements are objectives that a subject can achieve during the game, which can be explicit or secret, that is, that the subject discovers during the process of playing a game.

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allow to identify in which perspective it is situated, being able, in the same gamified process, to have the combination of both.

For the empiria, we opted for a gamification's perspective while cooperation and empowerment, starting the cartography that implies, initially, to make the daily life reading to identify the problem, as well as the context mapping, recognizing the different cultures which intersect within the AA-EAMD scope, to then have elements to develop learning situations, involving M&D and initiate interventionist practice.

At the first AA-EAMD's face-to-face meeting, a dialogue was held with the purpose of getting to know the students, as well as their needs, goals and expectations[6.] After this, it was presented to AA the objectives, the gamification proposal and in the sequence it was opened to discussion. Both the research was presented and the Free and Informed Consent Form was completed at the same meeting.

After these initial steps is that we began to think about the types of elements, strategies, M&D that could help ensure that students feel the way they want and can achieve the goals they want as well as by what AA-EAMD want. One of the defined elements was that gamification would be developed in a hybrid and multimodal context, involving the mechanics of tracks, live tracks[7], tracks in QR Code, tracks in Augmented Reality (AR[8]) and in the gaining of powers (knowledge). In one of the physical face-to-face meetings, students, using their mobile devices, hunt the clues in texts, audios, videos, live clues, QRCode and in the RA, which would support the development of learning projects. Another element of the learning project could involve the development of any situation that may be analogical, digital or even hybrid.

In order to begin the gamification process in the second face-to-face meeting, the interactive narrative[9] was presented with the aim of enriching the students in the gamification's logic that served as the guiding thread for the Clans' creation[10], as well as the tracks and missions that would be built and traveled by the students. After the presentation of the initial narrative, the students were challenged to perform the reading of the schools' daily life that exerted teaching activity or had access to develop the AA's proposal. This activity had the objective of finding a problem in the school context for which the games and gamification could contribute to the solution.

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6 It was also made available in Google question forms in order to know the students' profiles.

7 People who have a specific knowledge related to PAGs, who were invited to interact with the students.

8 Using the Aurasma.

9 There was a particular time in the world's evolution history in which formal education institutions have lost their sense both for the learning subjects and for society, and thus, the entire educational system has collapsed, since there were so many problems that while the institutions could think of ways to solve them, the feeling was of total frustration. Linked to this situation, humanity was going through a deep crisis of values and ethics. All seemed lost, when then appeared a group of people who created a Clan called the Reign of Virtual Reality (REVIR), where everyone shared the same belief, that it was possible to build an education that made sense for the subjects and thus contribute to change the world. In this Clan there was no hierarchy, all members were potential leaders who could contribute to change what they wished to see in Education. It was then that they began to organize themselves into smaller Clans, each one with the aim of better knowing these problems. Thus appeared the Clans [21].

10 Clans are family organizations presented during Antiquity and Middle Ages which acted as programmed devices to safeguard ownership of the property or to defend their own survival, bringing together several individuals by consanguineous bonds or solidarity of its members without there being a line of common descent among its members [4].

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The problem was the agglutinative factor that united the students for the formation of the Clans. In order to do so, the work in the Clans involved the accomplishment of missions with objectives and achievements, which were inspired by the traces of the cartographic method of intervention research, more specifically, in the four varieties of the cartographic attention (Tracing, Touching, Landing and Attentive Recognition), adapted as a methodology for the development, follow-up and evaluation of the learning paths, carried out by the students. In each mission, in addition to the goals and achievements, there was a set of human tracks (Live Tracks) and non-human tracks (Online Tracks in QR Codes and RA).The expansion of the level of EXP or XP (experience), which allowed to progress in gamification, occurred to the extent that the students would unblock the achievements of each mission (learning).

For the development, monitoring and socialization of their productions, the Clans used DT such as Moodle, Evernote, Facebook (fan page and groups), Metaverse Second Life, Google tools, YouTube, Prezi, blogs, and others. It was through these DT that the theoretical, methodological and thematic subsidies were socialized so that the students could compose, together with the material that they researched on their own, a set of information to base the production on the Clans. During the physical encounters, the Clans were able to share experiences, highlighting the building process, finding and interacting with live clues, deciphering puzzles on QRCodes lanes, accessing clues in RA and discussing the experiences that were taking place.

The evaluation of the students' learning was developed in the monitoring of the learning process of each subject, while conducting their course, enabling the achievement of powers (knowledge built) through weekly records in Moodle's learning journal. Weekly registrations were also made in the game logbook or process with photo, audio, text and video registrations in Evernote, fan page and blog.

In this learning tracking movement were realized a self-evaluation, peer evaluation and evaluation of the teacher in Evernote/Facebook groups. The possibility of gaining more power/experience (XP or EXP) occurred to the extent that the subjects broadened the observable (depending on the meaning assignment to the theory under study); they sought and indicated relevant references (texts, audios, videos, games, applications, etc.); they evidenced autonomy and authorship behaviors in the interaction and construction processes of the thriving learning project; they created networks of interactions in the Clan and among the Clans; they proposed questions, socialized reflections and performed reviews; they shared knowledge, collaborated and cooperated with each other. Results, discussions and final considerations are now presented.

5 DISCUSSION. RESULTS AND FINAL CONSIDERATIONS

Considering the research's problem and objectives previously explained, some results of the quantitative and qualitative analyzes are presented, followed by the discussions and final considerations.

The survey, whose empiria was developed over the three years that It lasted, Involved 166 undergraduate students, 04 female doctoral students and 01 Bachelor Degree in Pedagogy female student, monitor at the AA. Thirty-five projects were carried

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out during the research, resulting in games or gamified processes, coordinated by the academic students and with some kind of involvement of basic education schools or social projects. It is only during the four semesters of the years of 2015 and 2016 that the developed gamifications involved: 18 municipalities; 24 schools including municipal, state, private and NGOs; 59 education professionals; 240 parents, community professionals and around 454 students from kindergarten to 8th grade, including adult education, students with Down Syndrome and NGO projects.

In the development scope of educational alternatives to current DE models, the games and gamification, when linked to the cartographic method of intervention research, adapted while interventionist teaching practice associated to the learning projects methodology and to the flipped classroom and BYOD concepts, they were revealed while significant methodology and practice to the current learning subjects, considering their culture and evidenced in the way that they learn in different contexts. This methodology and practice have led:

- the linking of the pedagogical practice in the AA-EAMD context, with the schools daily life reading, allowing a strangeness and a critical analysis of reality from the relations establishment with the studied theories, which allowed students to identify problems, where games/gamification could contribute as possibility for changes;
- an effective engagement in the teaching and learning processes, mainly because they allowed them to live an experience in which they were challenged to explore and carry out missions, which put them in control of the process, thus enabling, through their constant actions and interactions, to discover and to invent ways and solutions and making decisions. All this in a fun way, favoring immersion (flow state), the agency and the transformation;
- type of interaction in which the different subjects (student and teacher) were engaged by performing exchange of information, sharing experiences in a learning process just by doing it, which favored the role and the development of social autonomy and creative authorship. This is fundamental for the subject to attribute senses (understand), learn precisely because he is experiencing an experience, "being in the situation" - which allows him/her to speak "from within" from his own learning process. Thus, by speaking "from within" what is being lived and experienced, the subject becomes part of this hybrid, attributing meanings, signifying and producing movements, as one of the human actors that is associating with other human and not human actors the constitution of different networks that are being woven into the multimodal perspective;
- the experience of this practice in the connection with the learning path walked through by each Clan in the development of the game or gamified process in the school, resulted in greater engagement of the students in the AA-EAMD; in the meaning amplification on the learning that occurred from this experience and; in the re-signification of the experience lived in the initial formation for the Elementary School, allowing the students to assign sense to the teaching in the Contemporaneity.

Participating in a game or gamified process and simultaneously performing a game or gamified process at school enabled AA-EAMD students to have a deep sense of con-

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fidence and self-esteem, which contributed to the flow of learning. By being able to identify problems in observing the schools daily life and contributing to their solution, students have experienced a positive sense of achievement and competence, further motivating them to the next challenge. The organization by Clans, together with the challenge proposed in the narrative that involved performing missions, instigated the collaborative and cooperative practice, since they had to define strategies and organize themselves to develop the game and/or gamified processes.

Still with regard to the methodology, it is important to emphasize that the cartographic research method, as an interventionist pedagogical practice in games and games processes and developed in a hybrid, multimodal and pervasive context, it allows accompanying the subjects in their different learning pathways. This monitoring involves the use of analog and digital technologies, both physical and online and encourages them to develop their own missions and projects that, from the BYOD's perspective, can extend beyond the time set for formal education.

The fact that the subject possesses a mobile device and being connected creates conditions for him/her to remain engaged in the process, regardless of time and space. Thus, the monitoring and evaluation process can, at different times, be "situated" and still imbricated. Through the designed and planned tracks in order to provide the analog and digital spaces hybridization, it was possible to establish a multimodal context, which is desirable when talking about immersion, agency and engagement.

More specifically, with regard to the movements proposed by Kastrup [7, 8] regarding the cartographic method, since the development of this practice allowed that it was possible to evaluate the power of the method and the inadequacies that are perceived in the own gamification experience. The question that seemed to be the most challenging was to guarantee the unpredictability and rhizomatic openness of the cartographic method and attention. In this case, it seems important to consider that it is necessary to invest more and more in mechanics and dynamics that strengthen and value the players' narratives (as in the case of RPGs).

Therefore, it can be said that the research reached the proposed objective, which was to develop pedagogical alternatives to the DEs models, so that the methodologies and the practice were significant to the current learning subjects when considering their culture and evidenced in the form as they learn in different contexts, in order to foster a more effective engagement in the teaching and learning processes.

Understanding the games/gamification potential for the creation of new designs in DE occurred in the extent that the empiria was being developed, it was possible:

- the understanding expansion on how to develop learning situations which are capable of enabling an AA (discipline) to be configured as a space of coexistence, which was neither a co-creation process from a space that is proper to the teacher, in the interaction with the students' own spaces, which are translated in a process of constant permeability, being that both are co-learners and co-teachers. In this way, there was the possibility of transforming both into coexistence, having origin in the cooperative and collaborative construction process. For the teacher, learning this, understood as attribution of meanings, occurs in the teaching process itself

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while it is constituted. However, this is only possible if the educational relationship is built on the principle of trust and the legitimacy of the other in the interaction;

- the deepening and evolution in the design, initially proposed as a function of the developed course, propitiated by the articulation between: 1) cartography of the developed pedagogical practice; 2) return of the constant assessments, conducted by the students[11]; 3) the teacher's reflections about the developed practice – carried out at the end of each meeting with the students, 4) discussions at the research practice meetings[12] with the master's and doctorate's degree students; 5) theoretical and methodological deepening. In this context, we emphasize the contribution of the Actor-Network Theory (ANT), developed by Latour, Law and Callon, to understand the circulations movement, inscriptions, assemblages, mobility between human and non-human actors and; of the research-intervention cartographic method, adapted as an interventionist pedagogical practice, capable of potentialize the development of strategies, associated to the methodology of learning projects and to the concepts of flipped classroom and BYOD, in the configuration of Hybrids, Multimodal, Pervasive and Ubiquitous Living Spaces for learning;
- the discussion about the need to reconfigure methodologies, practices and curricula, as well as how to organize them in time and space based on everyday problems, capable to integrate different areas of knowledge, making it possible to construct learning paths in a way to contribute to an emancipatory and citizen education, which is more significant for the learning subjects.

Another result relates to the articulation with Basic Education, which provided powerful interlocutions, because, from the developed methodology, students who were already teachers were disarmed and challenged to rethink their practice in the classroom from the reflection about their own learning process about what their students also experience while learning (signification and re-signification).

This awareness is significant for the transformation of pedagogical practices, since the teacher begins to differentiate between: 1) the "use" of certain DT in education X the meaning of DT in their learning process, which enables the creation of learning situations in which the subjects operate these technologies, experiencing them in the construction of experiences that make possible the meaning in the learning process; 2) the "content broadcast " X the construction of knowledge; 3) the "apply" an methodology X develop a methodology; 4) the "teaching" X the construction of learning spaces. The results impact has been extended to students of Basic Education in the involved classes in the projects development that resulted in games or gamified processes, and to the schools, involving teachers, management team and parents.

Considering the quantitative and qualitative results, there was a significant social impact provided by the project, especially linked to Basic Education, which occurred

[11] Every week, the students evaluated the AA and the work developed by the teacher, with the purpose of correcting directions.

[12] The research practice is a curricular activity of the UNISINOS Post-Graduation Program in Education, in this case, developed in the context of the Digital Education Research Group GPe-dU UNISINOS/CNPq, linked to the Education, Development and Technologies research line, being that the responsible for the development of this project is the coordinator.

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due to the games and to the gamified processes that were constructed from the movement's perspective "Games for Change" (developed from relevant educational issues, identified in the context of Basic Education schools where the Pedagogy students worked, causing impact in the institutions where the games and gamified processes were developed). It is emphasized the involvement of the community, because, this being a strategy that works with the concept of extended classroom, depending on the theme addressed by the Pedagogy students in the development of the projects, it was necessary to interact with other spaces and professionals ("Live Tracks").

Linked to this issue, AA-EAMD enabled students to understand how the games and the gamification can make up innovative pedagogical methodologies and practices that value multiple social spaces, such as knowledge-building spaces, as well as to promote cooperation between schools, Community and social segments. This may be one of the possibilities for the reconfiguration of the current educational context that has received criticism because it is losing meaning for the learning subjects and for the society in the face of the sociocultural transformations nowadays occurring.

In this way, the social impact, due to the linkage with the schools daily life, instigated, within the scope of the research, to investigate the scope that the pedagogical methodologies and practices developed in Higher Education can have in the Basic Education when being experienced and signified by the learning students, and these (schools daily life) are also considered learning and training spaces for students of Higher Education, by integrating their training process.

Thus, the concept of the classroom and the "walls" of the university are broadened. Therefore, the research results motivated the expansion of the proposal through the development of a research project with Primary Schools of the Municipality of São Leopoldo (EMEF Irmão Weibert, EMEF Santa Marta and EMEF João Goulart), with the aim of intending and rethinking the interfaces between DT and education, as well as developing learning situations (built in a co-creation process, based on a critical reading of the school's daily life), using games and the gamification's concept to social change in perspective of the configuration of Hybrids, Multimodal, Pervasive and Ubiquitous Living Spaces, integrating school spaces, university spaces and city spaces, in order to promote education for citizenship.

Moreover, it is noteworthy that the project provided greater integration between education (undergraduate, graduate and fundamental), search (GPe-dU, scientific research, masters and doctor's degree training) and extension (continued teacher training), generating positive impacts for both schools where the games and the gamified learning projects were developed, as well as for training at different levels.

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Effects of natural user interfaces on user experience, activation and task performance in immersive virtual learning environments

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Abstract.

The rising digitalization of all life and work areas also rapidly influences higher education. As a driving force of "Industry 4.0" digitalization demands new digital ways of working and new kinds of human-computer interaction. These changed circumstances require new and technical competences of future employees. To prepare students for this, a technologically-oriented teaching and learning process as well as gaining practical experience is crucial. In this context, Virtual Reality (VR) provide new opportunities for practical experience in education, where they can further intensify the students learning experiences to a more immersive and engaging involvement in the learning process. In order to be prepare for the future working life, students have to learn to deal with new technologies. As a first step to use immersive virtual learning environments (VLE) for education and to understand more deeply which kind of experiences students gain while learning in immersive VLE an experimental research study has been carried out. The paper describes the theoretical background of learning in an immersive VLE. Then the user study, which investigates the effect of natural user interfaces on user experience, activation and task performance in an immersive VLE, is outlined. Finally, the results of the user study are presented and discussed.

Keywords: virtual reality, immersive learning, user experience, immersion, virtual learning environment, higher education, individual learning

1 Introduction

The rising digitalization of all life and work areas also rapidly influences higher education. As a driving force of "Industry 4.0" digitalization demands new digital ways

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of working and new kinds of human-computer interaction. This changes the requirements for today's and future employees and students. At the same time, the requirements for the education of those students and thereby for the teaching staff are changing. Apart from "traditional" competences like professional, methodical and social competence especially a confident use of media is demanded from today's graduates [1]. Media didactics are considered a central element in an academic competence profile for the working world 4.0. This means that universities play a key role in educating future employees for a digital working world [1]. The training of digital competences should ideally already start in school, because they also have an increasing importance in higher education teaching. To be able to teach and learn digital competences in higher education new teaching and learning concepts and media are required [1].

Due to the rising number of students, classrooms at German universities are overcrowded and thereby often provide bad learning conditions [2]. Traditional classroom teaching formats are usually unable to meet those difficulties [2], because they don't meet the demands of today's students and future employees of a global digitalized job market. Nowadays, the content-related-didactical design of higher education is shifting from a "one size fits all" teaching and learning approach to a "tailor-made" concept i.e. taking individual aspects such as prior knowledge and the needs and aims of every student into regard [3]. In this context, virtualized teaching and learning formats gain importance. They facilitate a more individualized learning process for students to meet their requirements in higher education.

The use of innovative hardware like the head mounted display (HMD) „Oculus Rift" opens up new possibilities to teachers and students in the process of teaching and learning. Theoretical knowledge can be transmitted in a more realistic and practice-oriented way during the course of studies by letting the students experience it firsthand. Especially conducting dangerous, expensive or spatially difficult experiments has become possible by the use of these devices. In addition, students can experience the working place of the future since industry 4.0 has not yet been implemented. Furthermore to that, VR can also be used to visualize complex and abstract processes. By its application new ways to an active explorative course of studies open up for students.

In order to fulfill the students' learning requirements, the technical and didactical interaction between immersive hardware and students have to be improved. Therefore, individual factors which influence the students' learning processes in a VLE have to be identified. With the aim of using immersive VLE in education as a teaching and learning tool, the effect of natural user interfaces on the user experience (UX), activation and task performance in a VLE has to be investigated. The paper describes the theoretical background of learning in an immersive VLE. Then the user study to investigate the effect of natural user interfaces on user experience, activation and task performance in an immersive virtual learning environment is outlined. Finally, the results of the user study are presented and discussed.

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2 Immersive virtual learning environments in Education

2.1 Immersive Learning by Virtual Reality

VR is seen as a future technology which gains an increasing importance in industry and research. The progress in this area is driven by the rapid growth of the enhanced performance of hardware and technology, for example new interactive tools and tracking systems [4]. The technological advances and the growing availability of VR facilitate the access to universities because of their easier use and the decreasing costs of HMDs. Hoffmann & Hu [5] define VR as a "highly interactive and dynamic form of simulation in which a computer-generated world or environment can be 'entered', and the three-dimensional (3-D) objects within it 'explored' using visual, aural, and haptic (touching) senses." VR technologies are attributed with an immersive effect, which is initially caused by technological impact. Immersion is the central element of VR, which distinguished VR from other Human-Computer interfaces [4]. One central assumption is that VR technology leads to greater immersion in the VE and in turn higher immersion leads to better learning outcomes [6]. For an increased immersion, the user needs a 3D perspective of the virtual environment which is often realized by the use of HMDs. There are two existing perspectives of immersion: a technical and a user or mental perspective. The technological capability of a VR system to foster immersion implies that the user is surrounded by VR so that barriers between the virtual world and the user disappear. This leads to a greater level of users' attention and focusing [7]. The users' mental experiences in a VR environment are generally summarized by the term 'user experience' (UX), which can further be subdivided into certain theoretical constructs like immersion, presence and flow, which are used in the following. A widespread definition of immersion is from Murray [8], who defines it as a state, in which a user is surrounded by another reality claiming his full attention. Witmer & Singer [6] outline immersion as a "psychological state" and state that the "degree to which they feel immersed in the VE [will increase]" by effectively isolating users from the real world. Furthermore, they assume that a "VE that produces a greater sense of immersion will produce higher levels of presence." Wirth & Hofer [9] share this view. In contrast to this psychological perspective, Slater & Wilbur [10] define immersion as a technical characteristic of VR systems and understand presence as a consequence of an immersive technology. Presence is defined "as the subjective experience of being in one place or environment, even when one is physically situated in another" [6]. In context of VE, presence means the experience of the VE rather than the physical experience [6]. The concept has its origin in technology research at the beginnings of VR in 1970. Presence is the most influenced and researched concept in the field of VE. In contrast to immersion, presence is commonly understood as a user variable and not a technological characteristic. Flow is defined as a reflection-free merging in smooth ongoing activities that have been under control despite high strain [11]. Moreover, someone is in a state of flow, when requirements and competences are balanced [12]. Flow is the most general concept of all three constructs, because the experiences are not limited to media use, but to a series of activities [13]. The concept has its origin in happiness research and was originally used in daily activities [11]. Research studies show that the state of flow has an influence on

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information processing and cognitive load [14]. Considering the state of the art, it can be assumed that technologies which have a greater level of immersion lead to greater UX when users interact with the VE. The question arises to what extent immersion influences task performance in VLE and how immersion can support the learning process in a positive way. Moreno & Mayer [15] state that “[t]he fundamental idea is that students who learn by participating in the learning task with a higher sense of being in the environment may learn more deeply than students who learn by participating in the learning task as observers.” Wirth & Höfer [9] add that in particular media with many features that promote presence are being referred to as immersive. The greater the immersion of a medium, the more likely the user experiences presence in the VE [16]. Applying VR in education can further increase the students’ learning experience to a more immersive and engaging involvement in learning processes [17]. The immersion into a virtual world offers students the potential to experience virtual objects and to interact with the environment. Thus, a constructivist perspective of the learning process can be encouraged, in which students learn in an active, self-controlled way in situational, problem-oriented contexts. VEs provide a setting that facilitates a more personalized learning process matching students’ requirements and offering a higher learning autonomy [18]. To confirm this assumption further empirical evidence is necessary, especially if immersive VLE are to become an appropriate tool for education.

2.2 Hypotheses derived from the literature review

From the literature review and state of the art analysis different hypotheses were derived for the study. The following hypotheses and results are an extract from all tested hypotheses of the study. These extracted hypotheses focus on the effect of natural user interfaces, in this case, the Oculus Rift, on UX, activation and task performance.

Table 1. Overview about the hypothesis

1	Usage of the Oculus Rift leads to a higher presence than usage of the laptop screen.
2	Usage of the Oculus Rift leads to a higher flow than usage of the laptop screen.
3	Usage of the Oculus Rift leads to a higher emotional activation than usage of the laptop screen.
4	Usage of the Oculus Rift leads to a better task performance than usage of the laptop screen.
5	Female persons have a lower task performance than male persons.

3 User Study

3.1 Study Design

To investigate the effect of natural user interfaces on UX, activation and task performance in an immersive VLE, a controlled experiment was developed [19]. The control experiment is set up as an experimental research design. The experimental group use an immersive HMD as the experimental condition. In this study, the Oculus Rift DK 2

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was used, whereas the control group is provided with a laptop screen as the condition. In both conditions, the movement controls in the VLE are equal. In contrast to the laptop screen setup, the Oculus Rift controls the field of view via head movement. The control group using the laptop screen use the W/S keys to go forward and back-ward, while they use A/D keys in order to go left and right in the VLE. Each participant has used either the laptop or the Oculus Rift alone, so that there was no communication between the participants. The process of the experiment is shown in Figure 1.

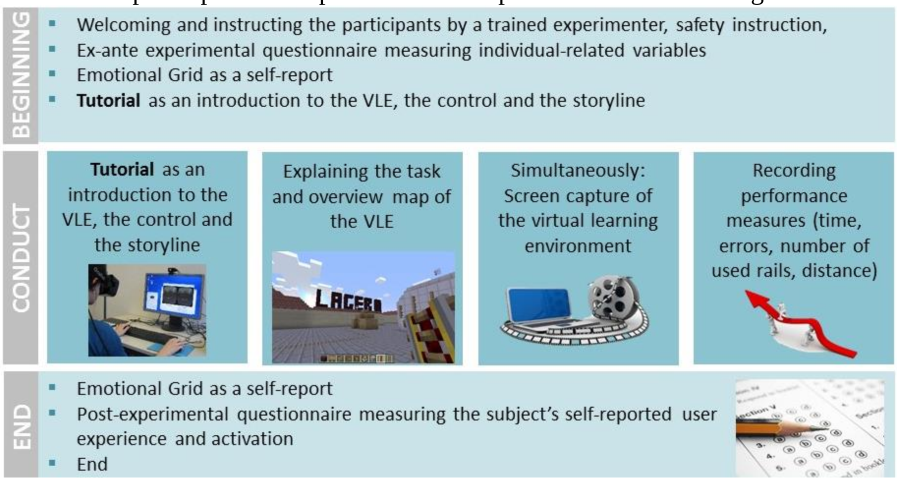

Fig. 1. Procedure of the study

The complete process of the experiment was proved in a pretest with 10 students from university in Germany at an average age of 24,9 years. In the pretest, the procedure, the measuring instrument and the experimental task in Minecraft was tested for didactical, technical and organizational improvements. After the pretest, slight modifications in the experimental task have made.

3.2 Measurements and Variables

To assess the relationship between the immersive capacity of the user interface, UX, activation and task performance in a VLE, a set of independent and dependent variables is defined. As independent variables, the following constructs are under study: Socio-demographic data, like age and gender, Personality traits (10 Item Big Five Inventory), Locus of control when interacting with technology (KUT) [20], Gaming behavior/ frequency of using games, Spatial cognition (Questionnaire Spatial Strategies, QSS) [21], Immersive tendency (Immersive Tendency Questionnaire, ITQ) [6], Immersive capacity of the user interface. All independent variables are collected via self-report information in form of a pre-questionnaire with already existing valid and reliable questionnaires. To measure the gaming behavior, the frequency of playing games as well as the experience with Minecraft and VR Technologies, own questions were constructed following existing questionnaires. The immersive capacity of the user interface comprise the natural user interface, in this case the laptop or the Oculus Rift.

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As dependent variables, three variables are used: UX is measured via the following scales: presence (Presence Questionnaire, PQ) [13], flow (Flow Short Scala, FSC) [22] and game experience (Game Experience Questionnaire, GEQ) [23], Emotional Activation is measured with the affect grid as a self-report, Performance is measured via different parameters: time, number of used rails, errors in form of the number of removed rails as well as the travelled distance and speed of each participant. UX is operationalized by the constructs of presence, flow and game experience. Already existing reliable and valid instruments for those constructs based on subjective reports as a common method to measure UX [18] are used. All items of the pre- and post-questionnaire are answered on a six-point scale, ranging from 1= total agreement to 6= total disagreement. The six-point scale was used in order to avoid answers which are positioned in the middle as with seven-point scales. The methods (self-report and quantitative questionnaires) constitute a complex and detailed description of the conscious and subconscious UX of the students in the VLE.

3.3 Minecraft as the setting for the virtual learning environments

For the experiment, a VLE was developed in the open-world sandbox game Minecraft (see Figure 2). Minecraft is suitable for the use in different academic learning contexts like engineering or geography and for nontechnical learning scenarios like creativity, teamwork or specific skills [24]. Minecraft offers opportunities to explore a VE in a free, active and experimental way to build new objects. Programming capabilities from students or teachers are not required, which allows the application in education due to low cost, time and personal resources needed. Moreover, Minecraft has already been applied successfully in different learning contexts [25].

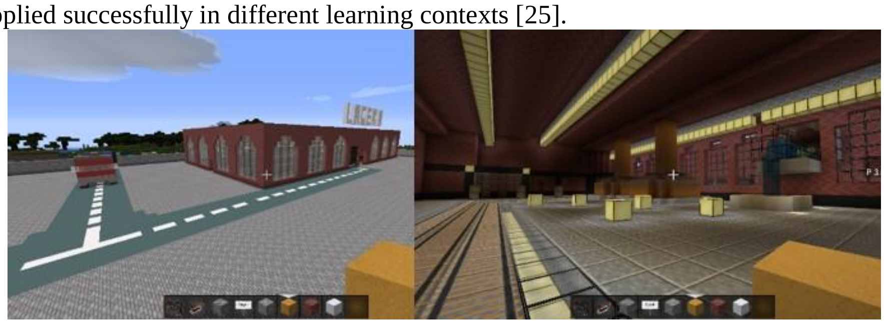

Fig. 2. Virtual learning environment in Minecraft (own image)

In order to use Minecraft as the setting for the VLE, the conception is following the game design steps according to references [26]: define the target group, define learning outcomes of the game, define the game, shape the game idea and elaborate the details (storyline), (technical) implementation of the game. The formulation of learning outcomes is one central aspect for a transparent and effective teaching and learning process. By this, students are empowered to value their decisions, activities and results in the learning process. The following learning outcomes are defined for the VLE: Spatial orientation, Decision Making, Problem solving, Psychomotoric skills.

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3.4 Experimental task

As an experimental task, a problem-solving process has been developed. Problem-solving tasks require a self-employed, active way of finding solutions. The above mentioned learning outcomes for the experimental task, represent the competence which students have acquired after solving the task. In this context, especially, competences in the field of soft skills are addressed. Students have different sub steps to solve the task. First a spatial orientation in the VLE is required. In a next step, a specific way has to be chosen from the students. During solving the task, students have to solve different problems in the VLE. Therefore, the competence of dealing with barriers and problems is trained. Because of that, the experimental task can be used in different teaching and learning domains, like engineering education, geography or communication sciences.
The experimental task is integrated in a storyline in an industrial factory setting where students are employees of a company that produces soft drinks. The students' task is to build a driverless transportation route on rails in order to transport freight from a warehouse to a factory. As requirements to solve the task, participants have to construct the transportation route on rails in an efficient, resource saving and fast way.

Before working on the task, participants have the opportunity to play through a tutorial to get to know the VE and the controls for movement and the field of view. Participants can practice the controls of Minecraft. Participants with the HMD can additionally use the tutorial to familiarize themselves with the HMD and the immersive effect. In order to record the performance parameters, a specifically programmed tool was used. The following task performance parameters were measured: time, number of used rails, errors in form of the number of removed rails and traveled distance of each participant. In addition to that, a screen capturing software (Open Broadcaster Software) is recording the student's movement within the VLE while solving the task. After the experiment, a qualitative interview with a semi-structure interview guide with the participants is conducted to get a deeper insight in the experience of the participants. The results of the experiment are analyzed based on a system of categories which was established through the deductive-inductive approach during the analysis. For the qualitative analysis, the software program MAXQDA 12 was used.

4 Sample and Results

4.1 Sample

56 participants volunteered to take part in the study. 50 % of the participants are students from RWTH Aachen University in Germany and 50 % are German high school students. Students were recruited via social media channels like Facebook and Twitter and via posters on the university campus. The participants received no information about the aim of the study. The only information they were given was that it is about the use of VR technologies in the learning process. Furthermore, the participants were informed about the randomization to the experimental and control group before the start of the study.

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In total, 29,6 % of the participants were female, while 71,4% of the participants were male. The average age of students was 19,56 years (SD = 4,67). The age range varies between 15 and 32 years. The majority of students (50%) have an engineering and scientific background (35,7%), whereas only 14,3 % of the participants study humanities. With regard to the conditions, 48,2 % (n = 27) of the participants had to use the condition with the laptop screen, while 51,6 % (n = 29) of the participants used the Oculus Rift. The gender relation is nearly equal: 50% of the female participants have used the laptop screen and 50 % of them have used the Oculus Rift. 19 (47,5%) of the male participants have used the laptop screen, whereas 21 (52,5%) participants have used the Oculus Rift. The majority of the participants (80,4%) are playing digital games, mostly on their smartphone to an average game time of 10,07 hours per week. In view of the use of VR technologies and Minecraft, 67,9 % of the students have already used Minecraft, whereas only 14,3% of them have used a VR technology before.

4.2 Results

The quantitative data were assessed with a questionnaire with closed questions before and after the study. All quantitative data were analyzed by using IBM SPSS, version 22. All hypotheses were tested with a t-test with an independent sample. The t-test was chosen in order to compare the mean from the two independent sample – experimental and control group. The constructs presence and flow were measured by already existing reliable and valid scales. The task performance were measured by the above listed task performance parameters. Emotional activation was measured by the emotional grid, a self-report measurement which include two bipolar dimension – arousal and affect [29]. The emotional grid was used before and after solving the task.

Hypothesis 1 *Usage of the Oculus Rift leads to a higher presence than usage of the laptop screen* is confirmed. The analysis shows that students using the Oculus Rift have a higher value in the subscale self-localization (M = 4.5, SD = 1.01), t (54) = -3.96, p < .01 and a higher degree of possible action (4.35 (SD = .02), t (54) = -2.75, p < .01 of the scale presence. This means that students using the Oculus Rift have the feeling of being in the immersive virtual environment and more possible actions in it (Figure 3).

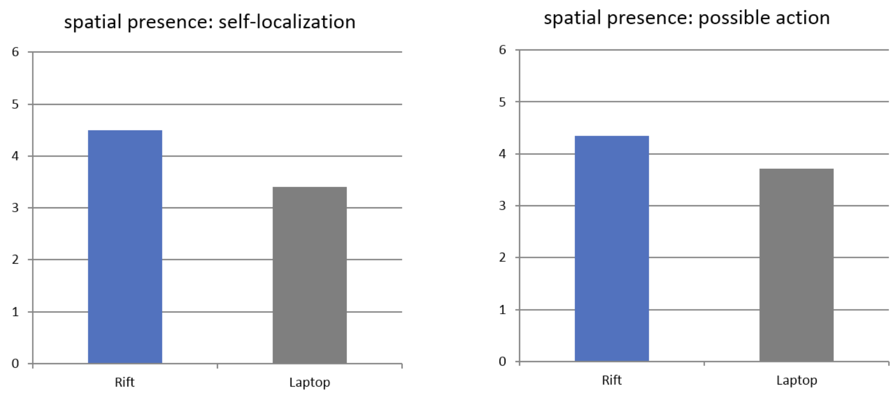

Fig. 3. Presence compared to the user interfaces

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Hypothesis 2 *Usage of the Oculus Rift leads to a higher flow than usage of the laptop screen* is not confirmed. The results show that especially using the Oculus Rift leads to less flow than using the laptop (M= 4.39, SD = .97), t (43,7) = 2.11, p < .05. Particularly obvious is the difference in the subscale "smooth and automatic run". The Oculus Rift User has a value of 4.5 (SD = 1.12) in comparison to 5.27 (SD = .65) of the laptop group, t (45.51). = 3.12, p<.01 (Figure 4). The correlation analysis of flow and the task performance parameters show that the subscale "smooth and automatic run" correlates with the time in the tutorial and the time to solve the task in a negative way. An explanation for the results could be the novelty effect of the technology or that participants with the Oculus Rift have less control of the Oculus Rift.

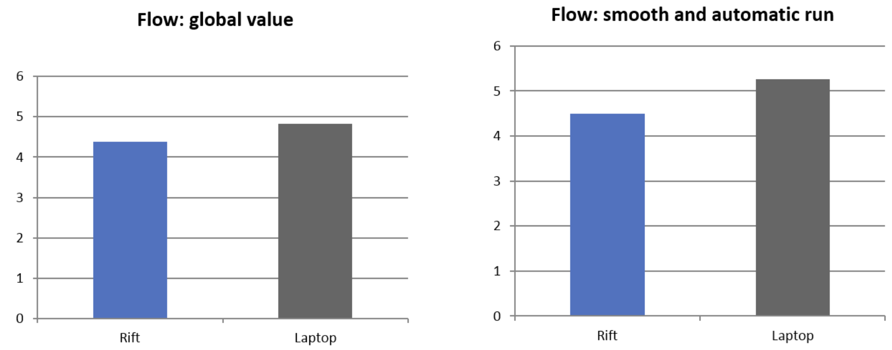

Fig. 4. Flow compared to the user interfaces

Hypothesis 3 *Usage of the Oculus Rift leads to a higher emotional activation than usage of the laptop screen* is not confirmed. Students using the Oculus Rift have reported more negative emotions after the task (M = 5.59, SD = 2.16), t (37.73) = 4.6, p<.00. The difference by comparison before and after the task is also more negative than by the laptop group t (36.93) = 4.53, p<.00. Regarding the activation no significant difference between both groups could be observed (Figure 5).

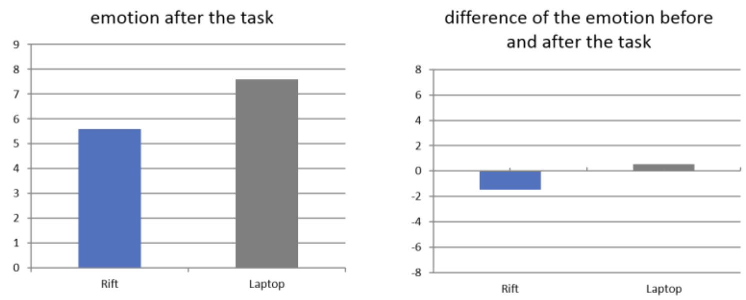

Fig. 5. Emotion compared to the user interfaces

Hypothesis 4 *Usage of the Oculus Rift leads to a better task performance than usage of the laptop screen* can be confirmed only to a limited extent. Students using the Oculus Rift spent 182 seconds (SD = 83,93) more time in the tutorial than the laptop group with 99,65 second (SD = 44.52), t (41,39) = 4.57, p < .00.

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Hypothesis 5 *Female persons have a lower task performance than male persons* is confirmed. Female participants needed more time in the tutorial (M = 208.88, SD = 131.13) than male participants (M = 125.35, SD = 67.49), t (18.27) = 2.42, p < .01. The results of the duration of solving the task are similar. Male Participants solve the task on average shorter (M= 313.93, SD = 179.51) than the female participants (M = 554.88 s, SD = 226.1), t (54) = 4.21, p < .00.

5 Discussion and Future Work

Concerning the effects of natural user interfaces, the results of the user study show that the immersive VLE leads to more spatial presence. Students who used the Oculus Rift report a higher self-localization and more possible actions in the VLE. These results are in line with previous research results which state that an immersive hardware leads to higher spatial presence [e.g. 28]. With regard to flow, there was an opposite effect than initially assumed and which is contradicted to the literature [e.g. 29]. Students who used the Oculus Rift had less flow than students who used the laptop. In particular, students using the Oculus Rift experience less flow in the subscale "smooth and automatic run". This is might be due to bad hardware. In the study, the oculus Rift development version (DK2) was used which has some hardware problems in comparison to HMD's which are available for consumer. At the time of the study, there were no HMD's for consumer available. Another reason for less flow could be that the Oculus Rift has distracted the user. A smooth and automatic run is characterized by focusing and concentration on a specific task. This might be due to general difficulties in handling new technologies and the novelty and unfamiliarity of HMDs as opposed to laptops. Students first have to get familiar with the technology, which takes the attention from the task and therefore they experienced less flow. The assumption that the Oculus Rift leads to a higher emotional activation than the usage of the laptop cannot be confirmed. In contrast, students using the Oculus Rift had more negative emotion after solving the task. Reasons for more negative emotion were identified in the conducted interviews with the participants. Difficulties with the controls, the perception and the properties of the visual presentation of the Oculus Rift were reported from the participants. Likewise, problems with dizziness, nausea and discomfort influenced the emotion in a negative way, which is confirmed through the results of the interviews. Another explanation may be that an intervention that was more focused on affective content would have given significant positive results. The comparison of the task performance parameter shows no significant differences between the experimental and control group except for the time in the tutorial. Students who used the Oculus Rift needed three times longer in the tutorial than the laptop user. The other task performance parameters show no differences between the experimental and control group. These results show that the habituation to new technologies balance differences in the task performance. Using tutorials to get to know the hardware is essential in order to use immersive hardware in the teaching and learning process. Statements of the participants given in the interview confirm these findings. Furthermore, the results in terms of task performance show that both gender as well as VR and Minecraft experiences influences

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the task performance in a VLE. With regard to use VR in education, practitioners has to consider the following recommendations: first the hardware and software must be available and an analysis of the target groups should be made regarding the group size, the topic of the course, the learning outcomes as well as the didactical conception of the course. The analysis of further hypotheses with regard to the effect of personality traits on user experience, activation and task performance is currently still running. Further research is needed in order to investigate which personality traits have a key function in this context. In further analyses, the results of the task performance has to be investigated in terms of their relationship to experience presence and flow in the VLE. A deeper insight on the participants' experiences will allow a more differentiated view on the focus of this research. This helps to get deeper insight into the specific preferences of students in education and their preparation for their future working life. The results serve as an important contribution for using immersive VLEs in learning scenarios in school and universities can be made.

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Improving Reading Literacy with an Immersive Learning App

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Abstract. The acquisition of reading skills is of high importance for a student's scholar success. However, we are facing a complex process and a significant number of 2nd year students still have specific learning difficulties. To answer this problem, Instituto Politécnico de Tomar (Tomar, Portugal) in a partnership with Agrupamento de Escolas Artur Gonçalves (Torres Novas, Portugal) developed the information system *Letrinhas*. This system includes an App for mobile devices, a digital repository of educational contents and an information management system. The interactivity and the real-time feedback offered by the mobile app led to an unmatched learning environment that presents excellent learning results. *Letrinhas'* architecture allows its adaption to the individual profile of each user and its sociocultural context. This puts the student at the center of the teaching and learning process. Teachers tested *Letrinhas* and its learning results were assessed. The evaluation's success led to *Letrinhas* being used for teaching foreign languages and extended to other schools.

Keywords: App, Immersive Learning Environment (ILE), Letrinhas, Mobile Devices, Reading.

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1 Introduction

Reading is fundamental for the individual development for it allows access to the environment and consequently promotes its personal, social and professional (re)building. Mastering reading skills outstands the individual in this global and competitive world where only the competent readers dominate the mechanisms that allow them to critically access knowledge as a way to actively participate in the society.

However, learning how to read is a complex process and not all students reach the desired proficiency level. For this, it is fundamental to invest in the development of projects that give an early answer to the detected difficulties, for prevention is key to the growth of well-succeeded readers.

The Basic Education Portuguese Program has the following objectives for the 1st cycle:

- […] Use the language fluently, mobilizing several verbal and nonverbal resources, and timely using technological resources.
- […] Acquire, interiorize and automatize the processes that allow the decoding of written text, aiming for a fluent individual reading.
- […] Develop and cement the written texts' reading ability for different genres and with different themes and communication intention [1].

The number of students flagged with learning to read difficulties has substantially increased with a special incidence on the scholar population of the 1st and 2nd cycles [2]. This is the reason why several authors [3] [4] defend that research in the scope of reading must focus on three aspects: early identification, prevention and reeducation. However, teaching and learning how to read implies the use of diversified strategies from the educators but also the students' motivation and reading habit. As Sim-Sim [5] refers, the learning how to read process is complex and requires students' motivation, effort and practice.

The need to identify ways of promoting reading skills acquisition and helping teachers meet their curricular goals established by the Ministry of Education is the origin of this research work, inserted on the "Ginásio de Leituras" project. This is a project by Agrupamento de Escolas Artur Gonçalves that involves the design, implementation and evaluation of a program to promote oral reading fluency, a key indicator of reading proficiency. Based on this problematic the research question formulated was: *how to promote reading learning with the use of information technologies in a more attractive, personalized and immersive way?*

Facing the inexistence of tools, in the Portuguese panorama, that could enable students' evaluation and the reading fluency improvement, the already mentioned Agrupamento and Instituto Politécnico de Tomar began the development of an information system - *Letrinhas*.

This system explores information and communication technologies' potential, notably mobile devices, respecting students' learning rhythm and allowing them to learn anytime and anywhere through interactive contents that lead to a more immersive learning.

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In this paper we describe part of the research done in the domain of reading promotion and present the system Letrinhas. Its use in classroom context is described and its evaluation results are presented. At the end, we list some conclusions and describe future work.

2 New Pedagogical Approaches to Promote Reading Literacy

Lately we have been watching the emergence of several tools and pedagogical strategies based on information and communication technologies for reading promotion.
Amongst those tools is GraphoGame, developed by the University of Jyväskylä in collaboration with the Niilo Mäki Institute [6]. Although this tool was created for children with dyslexia it can be used with any child that presents difficulties in learning to read. It is an educational game that makes learning to read easier and more fun, and according to some studies, it makes students "significantly better readers on most measures than the children […] receiving only traditional remedial teaching" (p. 52) [6].

Mystakidis, Lambropoulos, Fardoun and Alghazzawi [7] “used 3D VIEs as a digital medium to narrate a transmedia story, visit various virtual environments and immerse learners into different times and civilizations” (p. 1) with the objective to “motivate and promote the early literacy and extracurricular reading” (p. 1). The success of this project led to its expansion to other schools.

Lan, Sung and Chang [8] developed a learning system grounded on mobile devices to learn English as a second language and the studies show that this tool “seemed to reduce anxiety in elementary EFL learners, promote motivation to learn, and enhance oral reading confidence” (p. 142).

Gupta [9] presents a teaching strategy that “uses Karaoke as a tool to build and enhance reading behaviors such as fluency and motivation as a twofold purpose for struggling readers” (p. 80). According to this author, “the joint delivery of music and text provides an exciting, immersive experience for the child” (p. 84) with excellent learning results. Duolingo (https://www.duolingo.com) is another popular language teaching tool that can be used for free on a personal computer or on mobile devices. It uses gamification strategies and the mnemonic method of repetition.

The success of these tools is due to its potential to make learning a more immersive activity. Nowadays, “technology enables us to recreate reality in a virtual space and provide a degree of authenticity that allows almost complete immersion of learners in given scenarios” [10]. It is central to captivate and involve students. For this to happen, immersive approaches are an important help.

Witmer and Singer [11] define immersion as "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (p. 227). According to Slater and Wilbur [12] immersion is "the extent to which a display system can deliver an inclusive, extensive, surrounding and vivid illusion of virtual environment to a participant" (p. 603). For Bystrom, Barfield and Hendrix [13] immersion is more related to multimodal sensorial stimuli facilitated by technology.

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Adams [14] states that immersion can be tactic, strategic or narrative. For this author, tactical immersion “is immersion in the moment-by-moment act of playing the game, and is typically found in fast action games”, strategic immersion “is a cerebral kind of involvement with the game. It's about seeking a path to victory, or at least to optimize a situation” and narrative immersion “is much the same as it is in books or movies. A player gets immersed in a narrative when he or she starts to care about the characters and wants to know how the story is going to end”.

For Pagano [15] “the future of technology-enabled learning is immersive. Immersive in the sense that I am “in” the learning experience and I am practicing doing the things that I need to do better” (p. 3). This idea is reinforced by the degree of attention that has been given to this concept where can be enhanced the iLRN workshops [16]. The author adds that “the future of technology-enabled learning is mobile, augmented, visual, location based, kinetic, and story-line driven” (p. 3) [15]. Within the listed characteristics, mobile is one of the clearest. The evolution and vulgarization of mobile devices created enormous educational challenges and opportunities, allowing for new immersive learning environments (ILEs).

Computers are being replaced by mobile devices, which are gaining processing and storage capacity that allied to portability and multimedia capacity, make them excellent work tools and unlock great opportunities for teaching and learning [17]. An inquiry led by Pearson in basic and high schools across the USA, shows that 81% of the students agrees that the use of mobile devices, specifically tablets, allows them to learn “in a way that’s best for them”, and 79% refer that these help them “to do better in class” (p. 11) [18].

Although some mobile devices’ apps promoting immersive reading are appearing, none of the ones that were tested allows the user to choose texts according to each students` necessities, to accompany the students’ learning process, or the evaluation of reading fluency in respect to the Portuguese Curricular Goals for the 1st cycle [2].

3 *Letrinhas*: Learning Environment to Promote Reading Literacy

The Information System *Letrinhas* is constituted by a digital content repository, an information management system (back office), and an App for mobile devices.

The information system architecture is based on JavaScript as a programming language. JavaScript is used through Node.js on the server and through the Cordova framework for the mobile component. Since the use of the App for mobile devices can occur in a place without Internet access, a CouchDB and PouchDB combination was chosen for a transparent synchronization. When the device has connectivity with a data network, it executes an automatic data synchronization procedure with the server (CouchDB) and saves the necessary elements for offline functioning in local databases (PouchDB). In the same way, it transfers from the mobile device to the server the tests and corrections made by students and teachers, respectively [2].

In the back office (https://letrinhas.ipt.pt) the system’s administrator manages the schools, teachers and students’ information. This is also the space for teachers to create

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learning and evaluation elements, to make them available, make corrections and consult each student's learning results.

The students only interact with the App, the visible part of the system. The App was developed in a platform that makes it available for Android, iOS and Windows and several screen resolutions. This feature allows the App to be used not only on the mobile devices made available by the school but also on the students and parents' mobile devices for out of school periods.

As a way to answer the students and teachers' needs, the App has two types of elements: information and evaluation elements. The information elements allow the teacher to make available the educational contents about the curricular programs while the evaluation elements allow the teacher to assess the student learning on those same contents.

Every element was created with the intent to make use of the main features of mobile devices, namely multimedia and touch interaction to create more immersive learning environments. The information elements can be based on text or images. The first ones allow teachers to make available sound and visual information about words. This makes it possible to present additional information when the student touches a word. This information may be the classes any word belongs to (e.g. verb, name, adjective), its meaning (e.g. synonyms, translation) and it can even reproduce a sound that represents the reading in a different language than the one it is written. The information elements based on images, work in a similar manner to text but the touch identifies a region in the image.

To assess the knowledge acquired by the students, several assessment elements were developed. These elements can be divided in two: ones that demand the teacher intervention, and others which evaluation is done automatically, allowing students its use in a more broad and autonomous way.

3.1 Reading Tests

The reading tests were the first to be developed and the teacher intervention is necessary for its correction. The students' difficulties are identified and texts are chosen according to each student's individual needs. The student ears the text through the teacher's recorded voice on the mobile device, allowing access to a correct reading in terms of intonation, speed and prosody. This is the reading model the student will try to reproduce with his own voice. The student can hear the reading as many times as he thinks necessary and the text has a synchronization system that allows the student to associate the words being heard with the ones written. When taking the test, the student reads the text and the system records his voice that can later be heard. The student can repeat the test if he is not happy with the result. The fact that the student can hear his own voice allows him to identify difficulties and tries to correct them in an autonomous way (Fig. 1).

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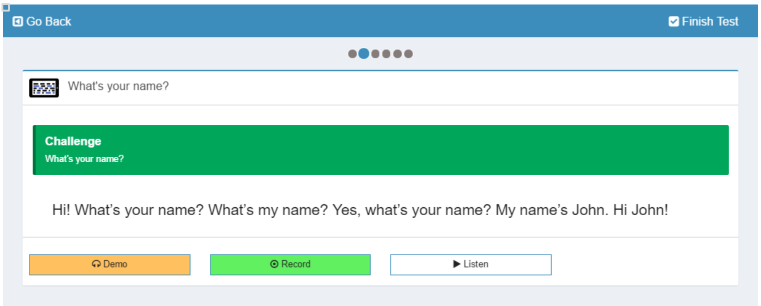

Fig. 1. Taking a reading test – voice recording

Evaluating the reading fluency is done through the correction of the test, by the teacher, that identifies the reading errors the student presented, namely accuracy errors (letter substitution; word substitution; additions; letter omission; syllable omission; word omission; inversions), and fluidity (hesitation; repetitions; spelling; word fragmentation; spontaneous rectification).

As the student's reading is recorded, the teacher can hear it as many times as necessary. Every time the teacher detects an error, the reproduction can be stopped to select the category and type of error committed. The system also allows defining the reading speed, one of the criteria established by the Portuguese Curricular Goals for the Basic Education defined by the Ministry of Education.

The words where the student made a mistake and the type of error are signaled in the text, and at the end the system makes an evaluation of the test suggesting a grade to the teacher. This grade is saved and allows the teacher to register and follow the student's learning evolution.

Simultaneously, the system identifies the words where the student had more difficulties and makes available a type of test where those words can be trained singly.

There is also another type of test that enables the evaluation of other reading inherent skills. As an example, we have the identification of words within a text such as verbs, names or other word classes the teacher chooses (Fig. 2).

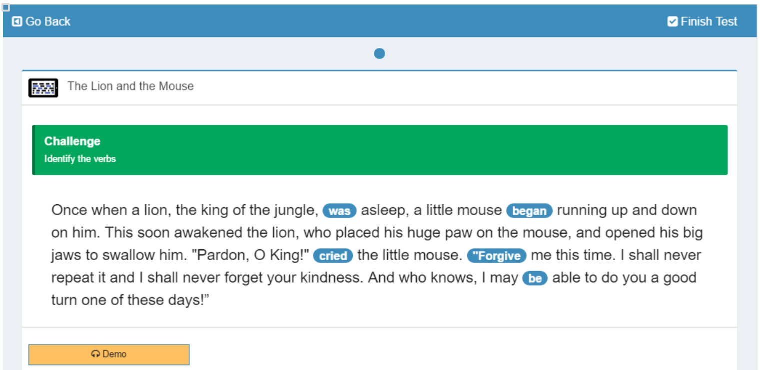

Fig. 2. Taking a reading test – Word identification in a text

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3.2 Auto Corrigible Tests

This type of tests allows students to receive immediate feedback about their answers. Auto corrigible tests try to be attractive. Here are some examples:

- Filling the blanks from a list of words;
- Dragging words inside sets;
- Selecting the correct answer;
- Multimedia elements connection;
- Selecting areas in images;

Fig. 3 shows the example of filling the blanks. When the student selects a blank space a list of words appears with several choices.

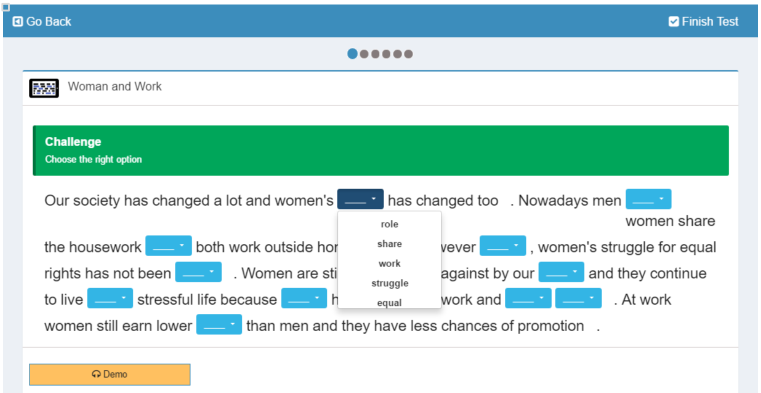

Fig. 3. Filling the blanks from a list of words

Fig. 4 presents the example where the student must drag words to the correct set (verbs or adverbs).

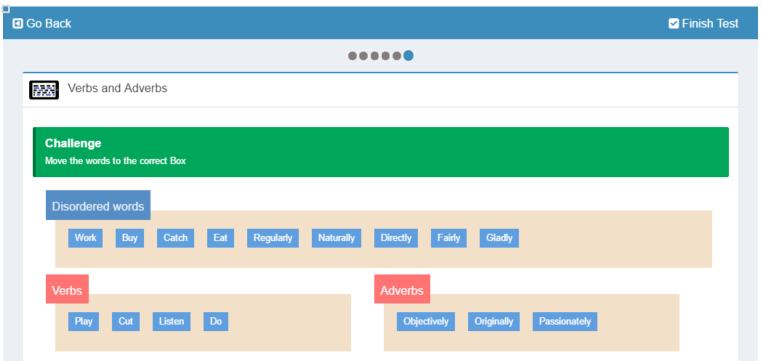

Fig. 4. Dragging words inside sets

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Fig. 5 shows the example where the student must identify which answer is correct. The question body can be an image, a text or a sound and the answers can be text or image.

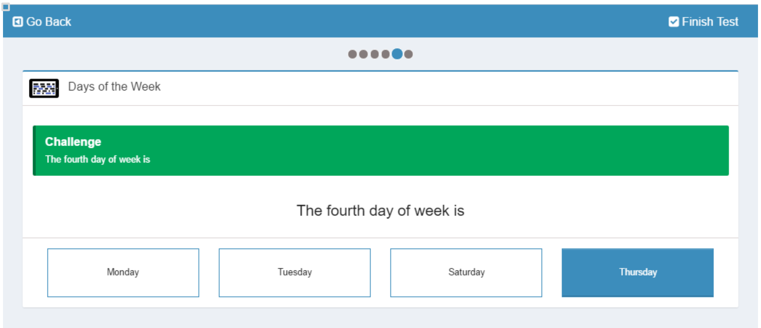

Fig. 5. Selecting the correct answer

The system also allows the connection of multimedia elements and the selection of areas within an image.

These elements can be used in different educational contexts allowing the adoption of contents to the individual needs of students and their sociocultural reality, providing a more attractive and immersive learning.

4 Teaching, Learning and Assessing with *Letrinhas*

During the school year of 2014/2015 *Letrinhas*' usability was evaluated by specialists and future users. The heuristic evaluation involved three specialists and the users' test was done with the 2nd degree class, three tutors and the class's teacher from Agrupamento de Escolas Artur Gonçalves.

For the heuristic evaluation a grill based on the heuristics defined by Nielsen [19] was used. The three specialists had experience in the design and evaluation of educational software, and had had no contact with the information system. Each specialist indicated the heuristics that were not being respected, describing the problem and presenting solutions. The suggested corrections were made before the users' tests.

The users' tests took place during a two-hour session in which 10 students with ages from 6 to 7 years old used *Letrinhas* individually under the supervision of three tutors. The tutors were teachers from the school and the children's teacher. The class's teacher selected students with reading difficulties.

The entire process was evaluated by the specialists to identify the difficulties students had while using *Letrinhas* as well as some errors that were detected and later corrected.

In March, during the evaluation year, *Letrinhas* was presented to every 2nd year teacher of the school where the test was done, and also to two special needs teachers, making a total of twelve teachers. All teachers were invited to use *Letrinhas* and to

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suggest changes and/or improvements. Their contribute was very important for the latest version of the system.

Letrinhas use in a real environment began in the school year of 2015/2016 with a pilot class from the 2nd year at one of the schools from Agrupamento de Escolas Artur Gonçalves. 12 students took part in this pilot study – 5 males and 7 females, belonging two to the 2nd year classes (once again, these were students flagged as having reading difficulties). With the pilot study it was intended to: characterize the work methodologies implemented by the teachers while using *Letrinhas* with students, and in the phases of creating tests as well as evaluating those tests; acknowledge the users' satisfaction degree – students and teachers – while using *Letrinhas*; and understand the impact it had on the improvement of the students' reading skills [17].

For this assessment, interviews and informal conversations were held, session observation and document analysis (teachers reports, class councils records and student evaluation documents). A pretest at the beginning of the school year and a posttest at the end of the school year were also conducted.

The obtained results revealed an improvement of the students reading skills. All the students overcame their reading difficulties such as stated by the teachers in their reports. It can also be verified that *Letrinhas* enabled the overcoming of reading difficulties in a shorter amount of time when comparing with data from previous years. It was also noticeable the high degree of satisfaction from those involved in this process while using *Letrinhas*. Students were always motivated and excited at the work sessions with it, taking every task with effort and autonomy (this is favored by the system characteristics because of the interactivity it permits). Teachers considered the tool as fundamental for their students' success. Their satisfaction is also related to the possibility of creating differentiated activities regarding each students difficulties as well as the ease of tests evaluation associated with the statistic information created by the system, which helps the evaluation task.

Since the system allows for the evaluation and accompaniment in real time of the students' learning, it enables the teacher to define the methodology to use with each student considering their difficulties or knowledge acquired [20].

Throughout the school year, teachers' opinion was collected about *Letrinhas*. The 33 participants had the opportunity to use the mobile app and the backoffice system. At the end of the year they fulfilled an opinion questionnaire. A semantic differential scale was used with values ranging from 1 to 7 [21], where 1 is a positive appreciation and 7 a negative appreciation.

Table 1. Teachers' evaluation of *Letrinhas*

Evaluated aspects	Average
Question creation and editing (Simple - Complex)	2.5
Test creation and editing (Simple - Complex)	2.4
Test correction (Simple - Complex)	2.5
Back office color enjoyment (Pleasant - Irritant)	1.9
Back office icons' suggestiveness (Suggestible - Not Suggestible)	2.0
Back office structure (Simple - Complex)	2.2

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Back office navigation (Simple - Complex)	2.0
Overall back office interface appearance (Pleasant - Irritant)	1.8
App color enjoyment (Pleasant - Irritant)	1.5
App icons' suggestiveness (Suggestible - Not Suggestible)	1.7
App Structure (Simple - Complex)	2.0
App navigation (Simple - Complex)	2.0
Overall App interface appearance (Pleasant - Irritant)	1.5

Participants considered it easy to create and edit questions and tests as well as correcting the latter. They liked the colors, icons, structure, navigation and overall appearance of the interface. The App got slightly better results than the back office. The majority of the respondents considered *Letrinhas* terrific describing it as fantastic, spectacular, excellent, interesting, very positive and good tool (Table 2).

Table 2. Teachers` opinion about *Letrinhas*

Category	f	%
Terrific	17	51.5%
Motivating/Stimulating/Appealing	7	21.2%
Of great use	3	9.1%
Functional	2	6.1%
Effective	2	6.1%
With great potential	1	3.0%
Eases the teachers' work	1	3.0%
Intuitive	1	3.0%
Should be available in every school	1	3.0%

Throughout the school year of 2016/2017 *Letrinhas* was integrated in the Promotion of Scholar Success Plan of Agrupamento de Escolas Artur Gonçalves. This project was financed by the Ministry of Education encompassing every student with learning difficulties attending the 2nd grade.

Letrinhas' versatility enables the design of new training paths that can be autonomously used by students in the classroom or at home.

5 Conclusions and Future Work

Acquiring reading skills is a decisive factor for learning success but despite the research in progress, specific programs, and the importance given to the Portuguese language, specifically to reading, we still find that the learning difficulties felt in reading lead 1st cycle students to failure, not only on their mother tongue but also on the rest [22].

Knowing that the reading difficulties continue to constitute one of the main obstacles to success and scholar performance, frequently originating difficulties in other learning areas, reflecting in the student's scholar progress [23], Instituto Politécnico de Tomar in partnership with Agrupamento de Escolas Artur Gonçalves presents *Letrinhas*, a tool

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that may contribute to overcome this problem using Information and Communication Technologies.

The use of technology is not new. Several authors such as Ferreira e Horta [23] consider that the use of computers offers many advantages to practice and develop reading skills, helping students to overcome their reading difficulties. *Letrinhas* presents a set of singular characteristics allowing the creation of personalized learning environments considering that each student has different difficulties; enabling the use of texts suitable to the student sociocultural reality; providing interactive learning environments; and offering students' learning management and evaluation tools.

There are many immersive educational environments, however "most of the proposals ignore the differences between students - which can contribute to the students' dissatisfactions" (p.1) [24].

The system's adaptability, attractiveness and interactivity make students strongly involved with the contents. It allows students to become fully involved in an interactive digital environment. *Letrinhas* can be seen as an engaging and immersive learning environment, regarding the interaction with the contents [25] and the gamification strategies, to meet authentic learning [26]. The enthusiasm is so great that students ask if they can keep using the App even after they have learned how to read correctly.

Considering *Letrinhas* success promoting reading at Agrupamento de Escolas Artur Gonçalves, its use was extended to foreign languages and will be presented to other groups of schools.

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Screenwriting Framework for an Interactive Virtual Reality Film

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Abstract. This paper presents a proposal for a screenplay writing framework for interactive VR feature films made using 360° video technology, presenting possible diegetic and extradiegetic interaction options on a pre-scripted story with different navigation alternatives. The interactive structure is based on the hero's journey and the classic cinematographic structure in order to assure the dramatic tension of the story. The framework for an interactive VR storytelling project can be applied in a Narrative Learning context. Both VR and storytelling have the potential to favor immersion and by this means favor the construction of innovative and effective learning environments.

Keywords: Narrative Learning, Interactive Digital Storytelling, Medium-conscious Narratology, VR Film

1 Introduction

360º video is one of the technologies with major possibilities to become a mass tool for virtual reality (VR) content production, due to its low costs as well as creation and distribution ease. After Facebook and Youtube habilitated the reproduction service on their platforms, a vast number of video makers have started to explore this new medium, using 360º video. The arrival of VR technology into the mass market has occurred in a multimedia context that offers not only 360° audiovisual reproductions but also the possibility to enrich the video through the addition of multimedia elements, offering multiple alternatives of navigation and extra information that enhances the experience. Approximately, 10% of the experiences on the Oculus Store are educational [1] and the field of Educational VR promises a big development in the next years as long as the creation of different kind of experiences and simulations increases and the virtual environments get massive access through internet. In this way, there will be a transformation from E-learning to VR-learning [2], as we also move from the era of information to the era of experience [3].

This screenwriting framework for an interactive virtual reality film is part of my PhD thesis in Immersive Interactive Narrative. The kind of immersive cinematographic experience that is presented in the dissertation can be applied in a narrative learning

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environment (NLE) [4]. Narrative has been proved as a powerful support for learning and skill trainer with regard to cognition, motivation and emotion [4]; the educational use of stories and narrations can be enhanced by multiple technologies and applied in the most diverse fields. In this case, immersive virtual reality (IVR) [5] is proposed as medium, due to the possibility that VR gives to "live" a virtual world with one's own senses and act directly into it [2], this activating a perceptive-motory learning type [6]; storytelling, moreover, works as a conductor that promotes a symbolic-reconstructive learning type [6], leveraging on our "narrative intelligence" [7].

This framework aims to become a conceptual tool for the authorship of a pre-scripted interactive narrative with multiple navigation alternatives in a 360º environment. The main contribution of the framework is to support the design of an interactive narrative that is independent of the user's journey within the story; the plot is always conducted into a dramatic climax, thus the audiovisual experience can be received by the viewer as a fluent and coherent story. This study relies on three elements in order to achieve a fluent interactive VR film: the immersive nature of VR, a well-structured pre-scripted story with special attention to its dramatic arc based on the classical cinematographic structure [8] and the *interactivization* of Campbell's Hero's Journey [9], as an instrument to stimulate activity in the audience, hence intensifying immersion and by this means learning and entertainment.

The next section presents the framework proposed to create immersive interactive 360° films, preserving narratological consistency on one side, and granting real interactive experiences on the other side.

2 Creating an interactive VR film

Theoretical research and artistic creation are working to improve understanding of how to tell an effectively immersive story [10, 11], borrowing some concepts from cinema, television, video and literature in order to design a story in a medium that defines itself day after day, thanks to users' feedback. Adding interaction in digital storytelling increases user's immersion, because having an active role contributes to enjoyment and learning. In a computer generated (CG) virtual environment, there are many possibilities of interaction with synthetic characters and objects, as actions and scenes are generated at run time. On the other hand, in a 360° video, where every scene needs to be created beforehand, the possibilities of interaction are mainly two: the definition of a bifurcated plot where every scene is a video clip, and the overlapping of multimedia elements over each video clip. These options can offer to the viewer a certain level of agency [12] inside the storyworld [13], despite the fact that all video clips are already created. In this sense, an interactive VR film is closer to cinema -as the name indicates- rather than to videogames, both representing different approaches to immersive

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experiences. In fact, one of the main issues in Interactive Digital Storytelling (IDS) from the creator's point of view is to find a good balance between a fluent story structure and the possibility for the user to have some level of agency within the story [14]: how to tell an engaging interactive story without compromising its dramatic progression?

The framework proposed in this study is applied to the development of an Interactive VR film set in Genoa's *vicoli* (narrow streets that form the old town). For the creation of this experience, the project takes as baseline the workflow of a traditional cinematographic project, being this stage the writing of the interactive screenplay. In the same way that Genoa's *vicoli* are a labyrinth of crossroads where the pedestrian is always forced to make a choice, the screenplay of this interactive VR film proposes a graph-based structure [15], using 360° video for the creation of each narrative node. As it happens in movies, the ultimate linear sequence of the videos that the user has chosen needs a dramatic tension that conducts the experience and keeps the viewer's interest alive during the experience. To achieve this goal, the interactive structure takes as foundation the classical cinematographic narrative structure proposed by Syd Field in his book Screenplay: The Foundations of Screenwriting [8]; hence the final experience -which results necessarily linear- can have a dramatic progression similar to watching a movie. Over this cinematographic narrative structure, it is proposed a way to render interactive the Hero's Journey [9]. The Hero's Journey is the result of the research of Joseph Campbell, who highlighted common patterns and basic stages through hero myths and stories from different cultures. This structure, that he called "monomyth", has inspired novels, movies and several artistic creations in history. The monomyth or hero's journey helps to creates empathy with the hero through the telling of a universal story.

2.1 Immersive Film

VR films have been one of the main interests of both technological and cinematographic big companies. Even though, from a narrative point of view, VR films are still in a phase comparable to the first film experiments like George Méliès's "*Le Voyage dans la Lune*", they encompass several genres, as witnessed by the variety of 360º videos shared in internet and social media, most of which are situational or landscape videos, non-fiction experiences. In recent years, the reproduction of 360° video has been the most used technology for videomakers and cinematographers who want to create VR environments. 360° video offers diverse benefits besides its low cost: on one side it is easy to use for those who are not familiar with CG software and, on the other side, it allows the recording of a real place or situation, offering an audiovisual reproduction of the real world. A 360° video reproduced on a Head Mounted Display (HMD) implies the complete cognitive immersion of the viewer into the storyworld; as

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the user simulates the story, his/her mind becomes the theater of a steady flow of pictures [16]. Thanks to recent technological development, the sense of presence within virtual environments is getting more realistic and motion-sickness is less likely, yet the physical experience may differ for every single person. VR provides a paradigm shift from previous interactive computer technologies allowing multisensory integration in a virtual environment that augments learning and entertainment with experience [17].

The study of how fiction's creation and usage change in a 360º environment, on one side, and how interactivity shapes the flow of the story and user's enjoyment, on the other, leads towards a *medium-conscious* narratology [18] for VR. The writing of a screenplay for an immersive film needs to consider in the first place the aspects related with the 360º environment. This conceptual exercise creates several narratological issues that haven't been completely addressed by theory: Who tells the story? Who is the user inside the story? Is the user part of the story at all? The creation of an interactive story is another challenge for the author: What kind of interactions are going to be used and in which way will they affect the story, how to write a fluent and coherent story where a single narrative node is both source and destination of another one or multiple nodes?

Even though interactivity is not an obligatory component to create an immersive film, in this study interactivity is added to a 360° video to enhance immersion. The discussion about interactivity is still one of the main issues of IDS, given that a real interaction is a logically conversation between two agents (human-human / human-computer), where each utterance makes sense with respect to the previous utterances and the agents' relationships [19]. The kind of interactivity that this framework employs is Interactive Fiction [20], a form of narrative based on a bifurcated story. In an interactive fiction users rearrange the fragments into other configurations [21], and the single interactions inside the experience are *reactive* [19], from a technological point of view, but challenging from the narratological/authorial side, in order to keep the flow and engagement of the user with the story.

2.2 Dramatic Pre-Scripted Structure

The main objective of this research is to create an interactive story with a dramatic structure, that leads to a climax; the virtual experience offered is similar to watching a movie, living inside the storyworld thanks to 360º video, and interacting with the story by having decisional power on the narrative development. This conceptual framework provides a way to *interactivize* a cinematographic experience [19, 22], yet without achieving completely interactive storytelling, whose creation requires more advanced technologies and techniques, such as Artificial Intelligence (AI), for the generation at run-time of consistent and interesting stories.

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At present, most 360º videos, both short movies and documentaries, are linear. Therefore, in order to create a non linear story with multiple alternatives of navigation, the proposed framework creates a graph-based preconceived structure formed by unique video clips that correspond to different stages of the Campbell's hero's journey. Each video clip represents a narrative node, so it can be a scene or a sequence already edited in post production. Each narrative node can be source or destination of another one or of multiple nodes.

The Aristotelian narrative structure [23] used by literature, cinema, television and radio dramas is based on the empathy between user and characters and on the obstacles that they need to overcome to finally achieve their goals. In the traditional film structure [8], the story develops itself in a paradigm of three acts: setup, confrontation and resolution. Generally, time is divided as follows: setup (1/4), conflict (1/2), resolution (1/4). The same time division occurs in Campbell's circle of the hero's journey, where key stages are represented as a circle that completes the whole journey: the departure from the ordinary world (setup), the entering into the extraordinary world (confrontation) and the return to the ordinary world with the achievement of the main purpose, that brings peace, mastering the two worlds (resolution). Each act contains specific turning points and stages that continuously add tension and contribute to user's engagement. The writing of this interactive screenplay is, in its first step, based on time and its subdivision in three acts (Fig 1); on the top of this canvas, the interactive narrative structure will be designed. Therefore, the user's journey inside the graph should conduct to a dramatic climax, because of the necessarily linear exploitation of the virtual experience.

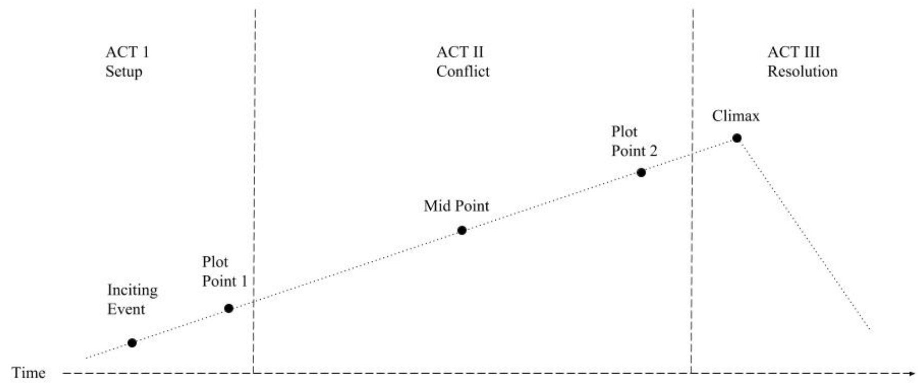

Fig. 1. Syd Field's Film Narrative Paradigm.

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2.3 *Interactivizing* the Hero's Journey

In the present study, the interactive structure goes through each stage of Campbell hero's journey as a linear expression of the cycle that the hero achieves in his/her path into the extraordinary world and return into the ordinary world [9]. Each act – *Separation from the ordinary world*, *Extraordinary world* and *Return* – is subdivided on stages of conflict, illumination, fear and overcome, victory and wisdom. Using the linear structure divided in three acts as a canvas, each stage can be located as an independent narrative node inside its correspondent act. The division of each stage and its location on the timeline allows the creation of a non-linear structure where the order and connections can be made following the specificities of the plot. The use of the dramatic arc as a canvas in which the stages of the hero's journey are juxtaposed, offers an overview of the dramatic progression of the interactive experience which is independent of the user's choices if each stage is located on the right temporal position. In this study is suggested a way to locate each narrative node inside the correspondent act, presenting different alternatives to diversify and combine stages. The choices used on this example are not restrictive.

Act I: The Departure – Setup. On Act I (Fig 2), the first possibility of interaction is related to the acceptance or refusal of the call that represents the inciting incident. These two possibilities (accept or refuse) have been regrouped into one single dramatic stage: the help of a supernatural agent. The simplicity of the interaction in this first act obeys not only to the narrative beginning of the story but also to the progressive multiplicity of the choices that the user will make along the development of the story. In this particular case, no matter his/her choice, the hero has to be conducted to begin the adventure. The call to adventure corresponds to the inciting incident, while the first plot point coincides with the first threshold, the entering into the extraordinary world.

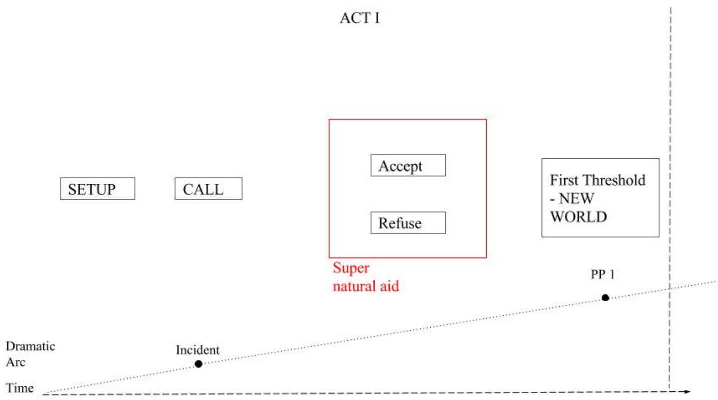

Fig. 2. First Act with interactivized Hero's Journey

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Act II: The extraordinary world – Confrontation. The second act (Fig 3) starts after the arrival of the hero into the extraordinary (new) world and the entering into the *"belly of the whale",* the stage in which the hero descends into darkness and discovers new truths about himself, emerging as a reborn hero. These two stages, as *setup* and *call,* are in this scheme represented as separated but consequential scenes. Scenes-stages can also be edited as one on postproduction in accordance to the plot or the production requirements of the project. From *The belly of the whale* stage, a number of trials are proposed; all these scenes are part of the *Road of Trials* stage. The Road of Trials is a series of obstacles and tests but also the moment in which the hero meets allies and friends. In this scheme three situations are represented: an *inner confusion* of the hero, the encounter with some *ally(s)* as well as the encounter with some *enemy(s)* and threats. Specifically, the encounter with a *deity/oracle* or an *obstacle/threat* are situated on the *Middle Point* of the experience, because according to Campbell, it is the moment in which the hero finds key information that will be helpful on the way to the climax. The *Middle Point* closes the first part of the story and opens the second.
At this moment, an example of double stage is introduced: the approach to the *Ordeal*, which in the scheme is represented with a *Right Approach* and a *Wrong Approach,* each stage adds dramatic tension before getting into the *Ordeal* or climax. This duplicity can be adapted to any stage of the journey.

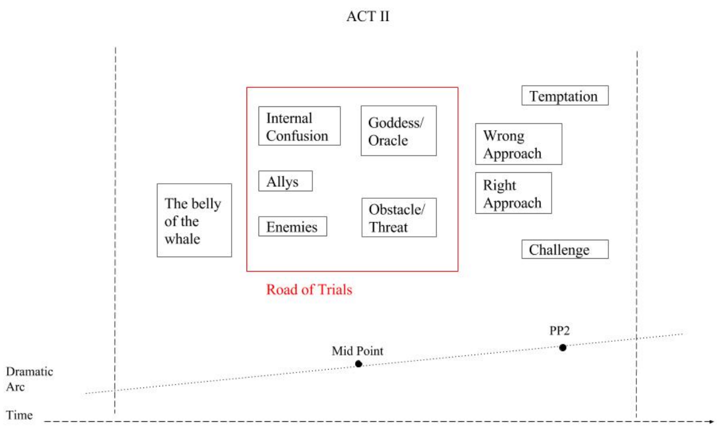

Fig. 3. Second act with Interactivized Hero's Journey

Act III: Return – Resolution. The last act (Fig 4) begins with the climax of the story, the moment when the hero is near to reach the key element that will bring peace and happiness. But as it happens in videogames, reaching the reward can be related to the behavior of the user, its attention to details and commitment with the hero's goal. In this scheme, as example, three possible endings are presented: one negative ending where the hero loses the reward and two positive endings where the hero gets the reward and can choose between two options for a happy life, *mastering the two worlds*:

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ordinary and extraordinary world. An interactive story with only one possible end could destroy the curiosity of the user to try other alternatives in subsequent usages of the interactive story.

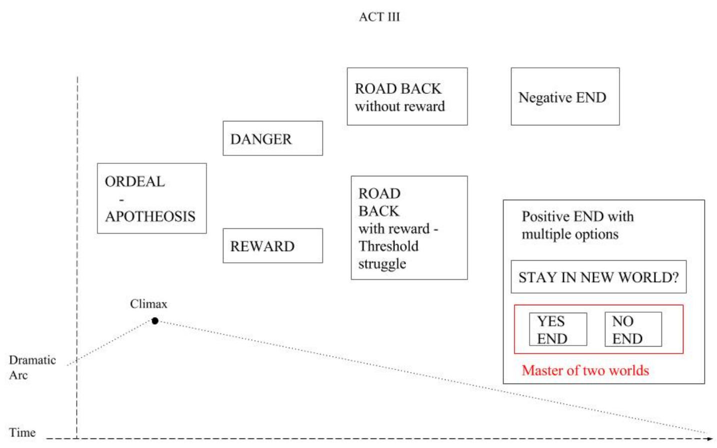

Fig. 4. Third act with interactivized Hero's Journey

The phase of screenwriting -which is a storytelling activity- is a complex and hard creative task, as it is the case in literature and cinema or any artistic work. This scheme offers a visual tool that may be used once the plot is already written and ready to be adapted to the interactive structure, but it also favors the writing of the plot's specific elements during the process of *interactivization*. The overlook of the whole interactive structure and the connections that can be made permits the writing of the plot based on the different navigation options.

2.4 Connecting the nodes

Interactivity is an instrument to incite activity in the audience and encourage them to immerse in the environment's content. In this particular case, interactivity works as the power of the user to select the next scene or to access additional information that enrich the experience. The addition of free information about the storyworld helps to augment the user's immersion [24]. The example presented shows how the stages of the hero's journey are individualized and organized in a temporary line that is divided into the three acts of classic cinematography, where the dramatic arc and its plot points are indicated. The stages of the journey can represent a unique scene or a sequence of scenes, previously edited, so each node corresponds to a unique video clip. Therefore, interactions can occur between narrative nodes (external link) or inside the narrative node (internal link). Interactions can be made through elements that belong to the storyworld (diegetic) or elements that are external to the storyworld (extradiegetic).

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External Links. External links connect a narrative node with another. They represent a change of scene or sequence, a dramatic situation that is different from the previous one. As in films, this change of scene or sequence can be given by the change of the diegetic time or the location. An external link that returns to a previous narrative node can present two possibilities: (i) what in movies is called a flashback or (ii) a return that enables the possibility to make a different choice. In the first case, the dramatic need of flashback responds to the search for key information to fulfill the plot. This information could have been already given but requires a second look or can be added by doubling the narrative node creating two versions of the same scene: the first narrative node and the flashback narrative node that contains the new information. In the second case (ii), the return to the previous narrative node that enables the possibility to take another path requires a number of versions of the same narrative node in correspondence with the number of links that this specific narrative node offers. In this way, it is possible to add free information and new details to each version of the narrative node (e.g. a non fundamental character that says hello or some casual situation). An external link can also conduct to an extradiegetic node which contains useful information that enrich the experience (e.g. instructions, learning content, historical facts, credits).

Internal links. Internal links connects diegetic or extradiegetic elements inside a single narrative node. Technically, the diegetic or extradiegetic hotspot is linked to a multimedia element (video, image, sound, text) that is overlapped above the 360° video or can transport to a new node that comes back to the same narrative node. Diegetic hotspots can be represented by the activation of an element inside the diegesis (characters, objects, sounds) that adds information to the narrative node. An extradiegetic hotspot is represented by an element linked to multimedia elements that do not belong to the storyworld but helps to enhance the experience through the addition of extra information.

3 Conclusions

The study offers an option for enhancing learning by merging interactive fiction and immersion, through the design of a virtual interactive narrative within a Narrative Learning context, in which pedagogical content from diverse fields can be conduct the storytelling. The main purpose of the framework is to ensure the linear progression of the dramatic arc independently of the journey shaped by user’s choices, in order to create a meaningful story capable to generate empathy and help the student immerse in the story's content. Such immersion is essential not only if the VR interactive video is created for amusement purposes, but also if the video has educational aims, to both favor the cognitive appropriation of learning content included in the story and to increase interest and motivation.

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This framework makes a step back on more complex interactive storytelling systems because it aims to propose a design method that can be useful to teachers and artist wanting to create interactive narratives. The scheme does not intend to be a unique solution for the screenwriting of interactive movies but tries to offer a simple way to organize and visualize an interactive story ensuring the progressive dramatic tension during the temporal linearity of the experience. The pre-scripted structure has been thought for being used with 360º video, a low-cost and easy to use technology, in order to create an immersive experience, but it can also be used with traditional video or a CG 360º environment.

4 Further work

This study can open the way to further investigations in many directions, such as exploring spherical virtual environments and the various possibilities of interaction between user and storyworld, being 360º video the medium used. At present, most of the interactions occur through visual hotspots; auditory hotspots could be added, using 360° sound. In this scheme interactions have been thought as conscious choices that users have to make along the development of the story, but it is also possible to determine the user's journey through its biological data (e.g., breath frequency or sweating) while he/she is living the experience. Also in such case of unconscious choices, the creation of an engaging and fluent story must prevail. From the educational point of view, it will be necessary to investigate in depth how to integrate learning content in a story without disrupting the story interest and consistency, nor the effectiveness of the interactive experience.

This screenplay canvas aims to be useful for interactive pre-scripted stories where any kind of Human Computer Interface (HCI) could be used to activate the links. Further research will be conducted in order to study the different HCI and its matching with the purpose of achieving a look-like cinematographic experience.

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Using Multiplayer Digital Games to Support Collaboration in Health Education

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Abstract: The research described in this article explores the value of a multiplayer game for supporting cooperation and collaboration in health education. The digital game was built using the game platform They Know. This platform was used because it enabled the development of team based strategy games in any subject area. The aim of a They Know game is for small teams of players to take control of the opposing teams home base, in order to win the game. The first team to take control of an opposing teams home base wins the game. To achieve this players have to cooperate within their team to develop strategy and share their knowledge about the subject matter in the game. To design a game in the platform subject matter is distributed across a game map in a network, with each node containing multiple choice questions relating to a specific learning objective or curriculum. In the context of this study the game platform was used for the development of an anatomy revision game, They Know: Anatomy.

Keywords: serious game, health education, multiplayer, synchronous learning

1 Introduction

Interest in the use of digital games for serious applications has been increasing since the early 2000s. However, there is a significant gap in the research into their use in health education. Although researchers have shown considerable interest in the repurposing of commercial games for enhancing surgical skills training, there are significant gaps in the broader application of games based learning in the health sector [1]. Currently, the literature on the use of digital games in health education has explored a diverse range of areas including their use for educating medical students about the delivery of care for geriatric patients [2], the use of digital games to assess mental preparedness of health professional sin training [3], and a number of studies investigating the impact of exposure to commercial digital games on predicting and enhancing surgical skills [4-5]. Further research is warranted into the effective use of digital games in health education and how they can be used to engage learners. This is particularly evident in regard to the use of multiplayer games to deliver immersive and collaborative learning experiences, as there is currently almost no research into their use in health education.

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A core component of health education is delivering training around foundational sciences such as anatomy and histology. Although these subjects are integral to health education, they are often challenging subjects for students to learn, due to the breadth of knowledge that has to be internalised [7] and also because of the complexity of the subject matter [6]. Students can also experience other challenges learning anatomy and histology such as a lack of confidence in their understanding of the material, as well as stress and anxiety attempting to internalise core elements [8,9]. As a result of these challenges there is considerable interest in the use of new technologies and tools for the delivery of anatomy and histology education to health students. There are currently two studies that have looked at the use of analogue games to deliver training to this group, a board game developed for medical students [6] and a card game developed for optometry students [10]. Both studies demonstrated the value of the games for improving anatomy knowledge of participants, and also for increasing their engagement with the subject matter.

The aim of this study presented in this article was to explore how multiplayer digital games support student engagement with anatomy and histology subject matter. Although there is some evidence that games can engage health students in anatomy revision, there is currently very little looking specifically at multiplayer digital games.

2 Methods

A mixed methodology was used to evaluate a multiplayer digital game used to support anatomy revision by medical students. Quantitative data collected included game platform metrics such as the number of subject matter nodes encountered by participants, the number of question cards encountered by participants and the number of question cards answered correctly by participants. Qualitative methods included unstructured observations of gameplay sessions, post-match surveys and semi-structured interviews with participants.

The anatomy game used in this study was disseminated using the They Know game platform. This platform was used because it supported multiplayer games, specifically team based strategy games. To win the game players cooperate with their team mates to cross the game map and take control of the opposing teams home base (Refer to Figure 1 for a screenshot of the game used in this study [4]). The game map distributes subject matter across a network of themed nodes relating to a specific learning objective or curriculum area. Each node contains multiple choice questions relating to its learning objective. Players start at their team's home node, which their team controls, and work their way across the network of themed nodes until they reach the opposing teams base. To cross the map players click on a node adjacent to the one they are on and attempt to take control of it for their team. To take control of a node players answer multiple choice questions until enough have been answered correctly to take control of it. A line of control must be created from the player's home base, through the themed nodes to the opposing teams home base in order to take control of it and win the game.

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Fig. 1. A screenshot of the game They Know: Anatomy showing how subject matter nodes are distributed across the game map [4].

In order to develop the questions for the game a team of content developers were identified. The content experts developed a suite of 240 multiple choice questions, which were distributed across 15 subject nodes. The subject nodes covered a breadth of areas including: Upper Limb Muscles – forearm and hand, Lower Limb – nerves, and Head and Neck Anatomy Once the content had been finalized a member of the research team used graph paper to design multiple maps, one of which would be used for the final game layout. Draft map designs were developed over a series of week in order to determine a layout that would encourage players to cooperate with their team mates in order to explore the maximum number of nodes. The successful map design was digitized and used during pilot sessions of the game in 2014.

Second year medical students were recruited in February 2014 to participate in gameplay sessions. During recruitment they were advised that the game was team based and that it had been designed to help them revise anatomy and histology subject matter that they had encountered as first year students. Participants were assigned to a game session, which consisted of at least two matches of the digital game spaced three days apart. Each match in a session was intended to be no longer than 60 minutes in duration. Participants who had expressed interest in participating in a gameplay session were emailed the dates of each session and invited to sign up for one that suited their availability. Up to eight participants could participate in a session, with participants being assigned to one of two teams of four players. All participants in a session played the game synchronously with the other players. Participants on the same team were co-situated in a single computer lab, but each had access to their own desktop computer. They controlled their own player avatar, but could see the movements of all other players across the map. Their team mates had blue avatars and those on the opposing team had red ones.

At the end of each match, participants completed a ranking of their engagement with the game. Once they had completed a session (consisting of multiple matches) participants were invited to participate in semi-structured interviews to explore the gameplay experience of each participant with the game. Each semi-structured interview was transcribed, de-identified and then analysed to identify common themes regarding the gameplay experience. Data collect from a session was analysed prior to the subsequent session being undertaken, so that the research team could iterate on

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aspects of the game itself and the gameplay environment, in order to explore different aspects of how multiplayer games supported cooperation and collaboration between participants.

3 Results

A total of three gameplay sessions were conducted during the study. There were eight participants in each session, with a total of 24 participants across all three. The demographic breakdown of the participants across all the sessions was 9 female and 13 male, with two female and six male participants in each of the first two sessions and six female and two male participants in the final session.

During these three sessions 43 post-match engagement rankings were returned by participants. Analysis of the post-match rankings indicated participants experienced a high level of engagement with the digital game, with 83% of participants ranking their experience engaging or very engaging (n=35). The post-match rankings identified competition as a particularly enjoyment aspect of the gameplay experience, with 90% of respondents ranking competition as enjoyable or very enjoyable (n=38). Finally, the majority of participants, 84%, agreed or strongly agreed with the statement that the game was repayable (n=36).

A total of 21 participants agreed to participate in semi-structured interviews to reflect on their experiences with the digital game. Interviews took between 10 minutes and 40 minutes, but most were around 20 minutes duration, and where conducted either over the phone or face to face at the participants' discretion. Thematic analysis of interview data indicated participants found the game beneficial for revising anatomy and histology content. The multiplayer aspect of the game was considered a novel way to support revision of anatomy subject matter that complimented existing autonomous learning approaches. It was identified that multiplayer digital games fostered collaboration through four elements: supporting the development of a team strategy to win the game, facilitating shared decision making to overcome obstacles during the game, working towards a shared goal, and creating a sense of investment in a team. The first element, developing a team strategy, was commented on most frequently by interviewees. It was considered beneficial for identifying the subject matter strengths and weaknesses of individual participants, and inform how the team traversed across the map. However, one interviewee commented that developing a team strategy may also have had made players less willing to expose themselves to subject nodes they felt under confident with, which could limit their exposure to new knowledge. The second element, shared decision making to overcome obstacles during the game, was identified by participants as an unexpectedly rewarding experience. Interviewees found the process of discussing questions and subject matter areas as a team provided them with insight about how well their peers knew the subject matter. This process made individual participants feel closer to their team mates during the game. Additionally, interviewees noted that the process could reduce feelings of social isolation and made them feel that other students were struggling with the same issues they were when learning anatomy and histology. The third element, working towards a shared goal, was identified as a positive attribute of multiplayer serious games by all the interviewees. Interviewees felt they had autonomy throughout the game to progress across the map as individuals, but also felt highly motivated to answer as many questions as possible correctly due to their sense of investment in the team. One interviewee also commented that they found the use of

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a multiplayer game were teams worked together to win for revising anatomy and histology subject matter quite novel, which made the overall experience more fun. The final element that that fostered cooperation and collaboration between participants was the structure of the team itself, and the way that encouraged participants to feel invested in their team. This element was not discussed by all the interviewees, but those that did raise it noted that it was a valuable one. Interviewees that discussed this element thought it gave them a sense they had a support system they could draw on if they need it. It was noted that the support provided to students though the support system may be enhance if teams were not randomly assigned, but instead structured to combine students who were stronger and weaker in the subject area.

In addition to reflecting on their own experiences during the gameplay sessions, interviewees discussed how they felt the game might be useful if it was implemented outside the confines of the study. Interviewees were particularly interested in the potential of the game to support user generated content, both in the form of the multiple choice questions themselves and also in the layout of game maps. Although the majority of interviewees raised the possibility of allowing students to create their own questions for future versions of the game, interviewees were divided about how this could be implemented. Some interviewees thought students should be engaged to write questions so that they aligned with their individual revision needs. However, other interviewees felt that students did not know what questions aligned with the anatomy and histology curriculum. To address this problem one interviewee suggested that students should create the questions for future games, and that a content expert should review them for relevance. Another interviewee suggested that some form of question development guidelines could be developed to reduce the likelihood of irrelevant questions being developed. Finally, a third group of interviewees felt that there would be no real benefit of getting students to develop the individual questions in the game, as that should be left to the experts. These interviewees felt it would be interesting if students could design their own game maps and distribute subject matter in a way that was relevant to them.

Finally, interviewees discussed the potential of multilayer games to encourage cooperation and teamwork more broadly in health curriculums. Participants suggested that embedding the multiplayer game early in the academic year could be beneficial for overcoming the challenge of encouraging interaction between students in large units of study. Finally, playing the game allowed participants to identify peers with subject matter knowledge and skills that complimented their own. This information was viewed as useful for making more informed decisions about forming study groups to strengthen self-directed learning and revision.

We acknowledge that this study had some limitations. The primary limitation is that the evaluation used relied heavily on participant reflection on their experiences with the game. Whilst that is a valuable means of exploring feasibility and acceptability of the game for learners, other measures are required to obtain additional insights into how multiplayer digital games foster cooperative learning experiences. Additionally, the demographic used in this study was exclusively medical students which limits the generalizability of our findings to other student populations. It would be interesting to explore the attitudes of other health students to multiplayer digital games in future studies.

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4 Conclusion

Multiplayer digital games have the potential to support collaboration in health education and to offer diverse and flexible and immersive experiences to learners. Additionally, they provide new avenues for supporting self-directed learning and encouraging cooperation between large groups of students, such as those in a tertiary unit of study. However, further research is still needed into the degree to which multiplayer games impact learning outcomes and value across a range of educational contexts.

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Enhancing strategies for cultural and natural heritage through the ALForLab Geographical Information System

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Abstract.
ALForLab' is a project co-funded by the National Operational Programme for Research and Competitiveness (2007–2013) that aims to the development and the integration of innovative technologies, improving the mobilization and utilization of forest resources, ecosystem services and the wood material of Calabria region, in Southern Italy. In this paper, we present the strategy applied to develop the ALforLab Geographical Information System Platform to exploit cultural and natural heritage from a touristic perspective, the methodology adopted to identify identity and perceptive paths of Calabria and the technological system and the devices settled along the touristic itinerary. In this case, exploiting technological devices, cultural and natural heritage sites can really innovate their communication methods and better enhance their fruition from a tourist perspective.

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Keywords: Digital Cultural heritage, Geographic Information System, Identity features, Landscape resources, Educational path and identity paths, Touristic exploitation, Immersive environments.

1 Introduction

Italy is universally recognized for its great cultural wealth, but the heritage is not only our past and present, it is also the future of the country, a resource that should be protected and enhanced, that makes it unique in the international scene (Serafini, 2015). Tourism is a key sector of our economy - 10% of Gross Domestic Product (GDP) - but beyond valuation of numbers and statements about our tangible and intangible heritage, the truth is that culture is not considered a priority in political choices for the development of our country.

In the last years, the interest that people show about heritage and cultural activities in general, is progressively increasing, thanks to a higher level of culture that has been improved considerably compared to the past, but also thanks to an instinctive attraction towards beauty (Serafini, 2015). These statements are demonstrated thanks to data provided by SISTAN (National Statistical System) and Statistical Office of the MIBACT (Ministry of Cultural Activities Tourism); from the analysis it is clear that, in the time series 1996-2012, the number of museum visitors (including in this category also monuments, archaeological and natural sites, etc. ...) is increasing continuously (Barbi et al., 2012).

Although cultural tourism remains a key segment of the tourism industry, which includes about 35%, in Italy the 17.6% of the Italians and foreigners expenditure is represented by expenses for cultural activities (i.e. 12.6 billion euro in 2012). For these reasons, it was necessary understanding how to direct the population interest towards cultural and natural heritage (Barbi et al., 2012).

In this context, we should consider that landscape is an immense good, which could be declined in different disciplines, as a touristic product; in this way, we could spread the landscape culture, the love and the attraction for this resource full of opportunities (Serafini, 2015). Landscape is an expression used to indicate the complex interaction between society and nature and the stratification of processes that accompanied the production over time, it is one of the most important categories of the UNESCO World Heritage List. Introduced into the system of the World Heritage Convention in 1992, with the term "cultural landscape", this category was chosen by many states worldwide to identify and protect areas of special beauty and great cultural and spiritual value. Today, there are 66 cultural landscapes listed in World Heritage List, belonging to different regions and cultures of the world, and they attest the wealth and the importance of landscape for the identity cultural of peoples (Serafini, 2015). For these reasons, the correct definition of landscape is the one that is described in the European Landscape Convention (ELC, 2000): "[...] it designates a certain portion of territory, as perceived by people, whose character derives from natural and/or human actions and their interrelationships" (Art.1).

Furthermore, in the Convention there is the first definition of identity landscapes: "[...] The quality of the landscape is, in fact, appeared for a growing number of European

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citizens, as an opportunity to reaffirm their identity, increase opportunities for physical and mental wellbeing and, simultaneously, promote a sustainable economic development" (Cartei, 2007).

In this context, Italy has a very special and privileged role. Its physical conformation, geographic location and rich historical events have allowed, in a relatively small area, the creation of a variety of cultural landscapes of extraordinary beauty, with few parallels in the world.

For example, the Calabria region offers an incomparable landscapes heritage forged by man, representative of the many historical periods and civilizations that have left footprints on our territory.

But the landscape question should be addressed in all its complexity, without any concession to nostalgic approaches, or to the illusory quest of a nature completely subtracted to human influence, instead considering its role as an added value for the rural areas development, for the conservation of the environment, and for the improvement of population quality life.

Questions are: is it possible to develop an analysis based on the economy of landscape? Is landscape a topic that can be examined according to logical categories of economic analysis? We can find a possible answer in the place marketing theory and strategies. The tag "place marketing" includes two concepts, marketing and territory, each of which has its own uniqueness; but also it contains three different metaphors:

- marketing in the territory: where territory is assumed as a market;
- marketing of the territory: where territory is a product;
- marketing made from territory: where territory acts as a business.

At the same time, the value of landscape derives from its ability to satisfy three types of questions: preservation of cultural heritage of which landscape is an integral part; preservation of people, territory and of their identity cultures; improvement of citizens and users welfare.

The place marketing has the responsibility to identify the needs of an area and define the most appropriate actions to fulfill them, so that there is a mutual benefit, economic and social, for citizens and investors (better defined as stakeholders) and customers/markets.

If we analyze the different activities that derive from place marketing strategies, there are many possible interventions. In general, however, we could group them into two main categories: the visible or just perceptible activities, and activities that generate or transfer value on territory (Tempesta, 2006).

The strategy that we have applied in this research project can be placed between the actions only perceptible and the actions that develop a change. In fact, the research work is based on the creation of "ALForLab" platform, a computer system able to promote and disclose the cultural and natural heritage and the identity of landscapes, to valorize and enhancing this heritage, and to promote an economic development through the tourism activity.

In this paper we present the "ALForLab" project and the strategy applied to develop the ALforLab Geographical Information System Platform able to promote and disclose

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the cultural and natural heritage and the identity of landscapes, to enhance this heritage, and to promote an economic development through the tourism activity.

This paper is structured as follows: Section 2 illustrates the contest of the project; section 3 illustrates the ALforLab Geographical Information System Platform created to exploit cultural and natural heritage from a touristic perspective, the methodology adopted to identify identity and perceptive paths of Calabria and the technological system and the devices settled along the touristic itinerary. Finally, Section 4 presents the conclusions of this work.

2 The contest of the project

The project 'ALForLab' (PON03_00024_1 - Co-funded by the National Operational Programme for Re-search and Competitiveness, 2007–2013) aims to the development and the integration of innovative technologies, improving the mobilization and utilization of forest resources, ecosystem services and the wood material of Calabria region, in Southern Italy. The 'ALForLab' Project activities are interwoven in a complex system because wood is a renewable material that has a wide range of uses (housing, energy, furnishings) and in recent years, has been the focus of sharp tensions on the market price. The specific objectives of the project aim to optimize the forest-wood chain, covering all the phases from production to harvesting and manufacturing, down to final products, with the aim of reducing the costs of wood mobilization and increasing the efficiency of the value chain. The reference market is represented by the enterprises working with wood harvesting and technology. Therefore, the main targets of 'ALForLab' Project are as follows:

- to develop advanced methodologies to monitor, inventory and build, in real time, the productivity scenarios of forest resources as well as the provision of "environmental services";
- to promote an integrated planning and management approach of the forest-wood-environment value chain, aiming at the development of a sustainable supply chain of biomaterials and environmental resources through the application of geomatics technologies and modelling;
- to define, develop and promote the control and reduction of the processes of ecosystem degradation related to soil erosion, extreme climatic events and forest fires while increasing the resilience of ecosystems and protecting the landscape from natural hazards;
- to identify, design and implement appropriate and advanced technological innovation of processes and products to increase the availability, quality and processing of wood manufacturing;
- to implement innovative procedures for traceability and eco-certification of forest resources while quantifying their role in climate change mitigation;
- to enhance and protect cultural and natural heritage (like woods), through customized strategies, which would also include the reuse of wood, and dissemination of results.

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GIS have been widely used in many areas of study and research, from geological and territorial studies (Carrara et al, 1995) to criminological investigations (Chainey and Ratcliffe, 2013), from real estate applications (Ciuna et al, 2017) to administrative purposes (Stevens et al, 2007). As far as we know, nothing has been done about landscape resources and identity features.

The benefit of this project is the integrated approach of the different aspects related to the forest-wood chain value, thus facilitating the optimization of the technologies and resources involved in the process. In this framework, our research group planned, designed and implemented the ALForLab Geographical Information System (GIS) with the aim to:

- provide a tool for the management of woods in the perspective of the landscape protection;
- identify a test area of identity landscapes within which to promote ecotourism;
- implement an information tool to support the promotion of development strategies in prestigious environments.

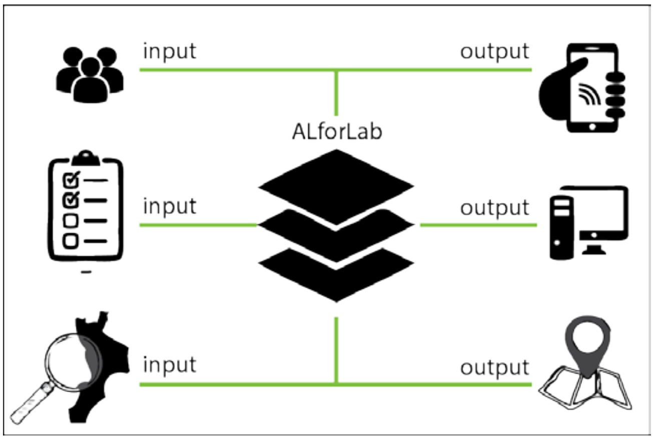

Fig. 1. Schematic concept of the ALforLab GIS Platform functioning

3 The ALforLab Geographic Information System (GIS) Platform

The adopted methodology was designed to create a digital cultural heritage management platform through digitization and georeferencing of local cultural heritage information. The main objectives are:

1. Identification, fruition and valorization of strategies of wood heritage of Calabria;

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2. Implementation of a Web-GIS geographic information system for the realization of a system for the protection and enhancement of identity landscapes of Calabria;
3. Environmental characterization of residential and touristic wooden modules;
4. Surveying to identify perceptive and educational identity paths of Calabria Landscape.

With reference to literature recommendation and to the project's specific aims, a logical design scheme has been outlined. The logical design is the first, principal and crucial phase of the database building and it involves participation of every member of the project in order to ensure semantical coherency. In fact, design foresees communication between the different groups of participants as they mitigate their differences, find common understandings, and find coherency (Harvey, 1997). The GIS logical design consists of a graphical scheme able to show the GIS architecture, highlighting the main aims required by the different members (Marble et al, 1972). Once the main GIS aims have been defined and the expected results have been identified (in terms of maps, reports, charts), the database scheme specifies the main feature classes, their geometric shape and the corresponding fields and data formats, and any domains or subtypes. The design scheme has to be reported in a graphic art, aimed to return in visual form the project structure. According to the design concepts, the database physical structure has been done using the ESRI ArcGIS® software, through the implementation of a personal geodata-base containing the following elements and feature classes:

- four different feature datasets, every one for each of the test areas (Sila, Pollino, Serre Vibonesi, Coast);
- four different layers for each dataset, containing information relevant for the purposes of landscape valuations, and in particular: a polygonal geometry layer to map forest resources; a punctual geometry layer to catalogue urban settlements; a punctual geometry layer to classify the Points of Interest (POI); a punctual geometry layer to position the wooden devices useful to eco-tourism activities (observation points, facilities for bird watching, information points, etc.);
- two networks to define both the identity paths and the perceptive ones.

For each of the feature class described above, the information fields with the corresponding domains and subtypes were defined. Geographical Information layers have been prepared according to technical and formal standards identified by the Directive 2007/2/EC of the European Parliament and Council of the 14th March 2007. The directive, which has led to the establishment of INSPIRE (acronym for Infra-structure for Spatial Information in Europe), provides guidance about the construction of layers and metadata relative to georeferenced environmental information, so that they can be homogeneous and shareable, and they can provide adequate support to environmental policies or any other activity that may affect environment. More specifically, the Directive defines the rules for:

- the metadata, that is, the data describing the data (description of geographic data within the spatial data catalog). The main objectives of a metadata system are:

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Search, Location, Selection, Semantic interoperability, Resourse management, Availability;
- Geographic data models and themes: INSPIRE defines three annexes of data specifications. Each of these annexes establishes a data model for each theme and a data structure to be respected for communication and data exchange in that particular sector.

The landascape GIS has also a cartographic base, consisting of land use informations (Corine Land Cover), roads' data and ortophotos, acquired from the National Geo-portal and from the Cartographic Portal of the Calabria Region. Once the physical structure of the GIS has been defined, the landscape data have been incorporated into the database, using their geographical coordinates. Settlements data contain attributes related to population and types of settlement (low urbanization settlements, rural towns, historical centers, permanent settlements), while landscape identity features, represented by Points of Interest feature class, give information about cultural and historical heritage, religious heritage, rural and natural heritage, industrial archaeology, highlighting whether their quality is officially recognized or not valuable. For each of the identified POI, through the hyperlink tool, an information sheet has been built, interactively connected to map. On the basis of the POI position and panoramic point of views, two different kind of networks have been built, one for the identity paths and one for the perceptive ones, showing information about type of path (vehicular or pedestrian) and travel time. Along the paths, the wooden touristic devices were placed, with a representative symbology for services inside (shelter, bus stop, toilet, info point, exhibition space, bookshop, terrace, bike repair, restaurant point, food distribution point). The landscape GIS database has then been made available on mobile devices for tourism purposes. The ALforLab GIS platform recognizes users' geographical position and allows them to discover the landscape identity features and the paths to reach them. This system allows to easily manage different data such as images, text documents, photos, videos, etc.

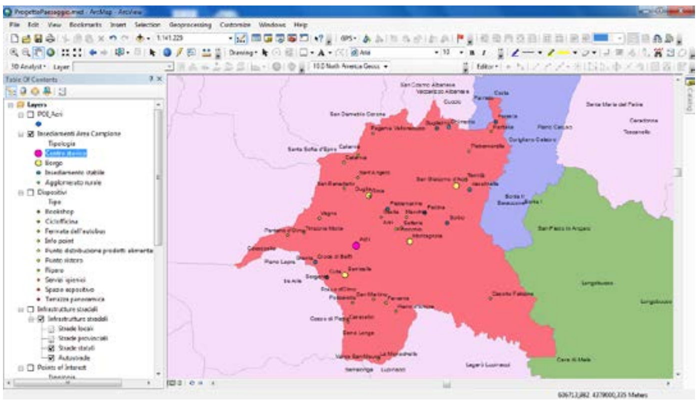

Fig. 2. Geolocation of the main settlements in the test area of Acri (Map View)

DOI: https://doi.org/10.3217/978-3-85125-530-0-17

3.1 Cultural and natural heritage: the Calabrian region and its exploitation from a touristic perspective

According to the guidelines on the importance of identity landscapes issued by the ELC, we have studied the identity characters of the areas of Pollino, Sila, Serre Vibonesi, and Coast. To do this, we have identified the identity characteristics of the following categories: woods, urban settlements and points of interest (POI), in order to be able to collect directly on the territory all the information and data necessary for the ALForLab platform development. It is important to point out that forest resources represent an important part of the cultural heritage, because they represent territorial and population's identity features. In particular, as regards the woods, we gave information on the type of trees, as regards the settlements we gave information on the type of plan, and as regards the POI we have divided them into industrial archeology, cultural and historical heritage, religious heritage and rural and natural heritage. After the general classification, we have chosen a test area on which we focused the research. The test area is the Bonis river basin; it is located in Sila, and includes the following three locations: Acri, Corigliano Calabro and Longobucco. At the end of the research conducted on these three communities, we have entered all the information, data, and results of statistical and psychological - perceptive surveys (Section 3.2) in the ALforLab GIS Platform.

3.2 A survey to identify perceptive and educational identity paths of Calabria Landscape

According as the European Landscape Convention (ELC, 2000), "landscape is the way how people perceived the environment". In this definition, the important aspect of the "social perception" is underlined, stressing on "how" people perceives the landscape. Yet, according to Shamsuddin et al. (2012), landscape perception is the result of interactions between natural, cultural and historical environmental components.

From a psychological point of view, it is really important to understand how subjects perceive landscape and what it represents from an identity point of view. Social representations of a phenomenon and, in this specific case, how people perceive landscape, can be influenced by the cultural and symbolic values, by popular beliefs, by economic interests, or by individual or social interests.

In this framework, a psychological survey aimed to identify identity, perceptive and educational paths of Calabria with the aim to better exploit landscape, has to take into account all the material and immaterial elements linked to the cultural identity (folklore, crafts, food, etc.), legends or historical events with evocative and/or educational power. Using the method of semi-structured interview, guided by a set of predetermined questions, we collected information with the following target of people: subjects that work in the touristic fields (tourist guides), agencies in charge of tourism promotion of the territory and old natives.

Thanks to this preliminary work, the interviews gave us important suggestions on the information to insert in the final survey.

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The final questionnaire has been developed by using Google Form. This digital tool allows to reach a larger number of users, contacting them also through social media.
The questionnaire consists of four sections. The first section is devoted to collect users' demographic characteristics (e.g. age, gender, level of schooling, residence) and their personal opinion regarding the activities that they believe interesting or useful during a touristic path in an old town, during a cultural or a religious route and during a naturalistic path.
Each of the three next sections, presents questions regarding the location belonging to the testing area (Acri, Corigliano Calabro and Longobucco) on some Point of Interest (historical, cultural, industrial, archaeological, religious, rural and natural heritage) that we identified through the preliminary interviews.
Users have to indicate if they know the mentioned Points of Interest. In the case of affirmative answer, users have to specify their opinion according to a three point Likert scale, where 1= "no value"; 3="high value". Also, we listed some cultural, religious, or festival events. Users have to choose which of them they know or they have participated in.
At the end, using the modality of open answer, users can indicate one or more historical, cultural, religious, rural and natural heritage or panoramic point or naturalistic route not mentioned in the questionnaire.
We planned to run a descriptive statistics. The results analysis will give important suggestions to support the GIS developers in improving and implementing the educational, identity and perceptive paths or to create customizable and usable navigation paths. In fact, as stressed by different authors (Mahdjoub et al., 2010; Paredes and Martins, 2011; Alfano, Carini, Gabriele, 2012, Bertacchini et al., 2015;) and Human-Computer Interaction (HCI) studies, the fulfillment of user requirements is an important prerequisite for the development of successful products on the market, to respond to the really end-user expectations.

3.3 Systems and devices: technological presidium of the territory

To make the intervention of identity and perceptive paths easily recognizable, visitors can find during the way specific objects that define the itinerary, which are useful for many functions. The most interesting points of the area are characterized with the localization of a device made of wood that has different featured depending on the surrounding context.
The project in fact aims to realize a wood prototype in order to make greater use of renewable raw materials available in the Sila-area, which can be use in different situation and for several scopes. That is why it is designed to be sustainable, flexible, temporary, easy to build and anti-seismic, able to host residential issues (social housing, temporary house, emergency house, places of refugee) but even tertiary sector activities (exhibitions, info point etc.).
To minimize the environmental impact, in addition to the use of easily available materials, it is important to focus on energy-saving solutions. The starting point of the research was the bioclimatic philosophy. The key-elements of bioclimatic design are pas-

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sive systems, which run without being dependent on mechanical equipment or subsidiary power supply, but deal exclusively with design and local resources. The passive strategies included suitable material selection, space layout and orientation, openness, passive ventilation, natural daylighting, shading and vegetation, especially when the device has the most complex asset and it has to be used as a house. Sustainable additions include a roof-based solar panel system, rainwater harvesting and gray-water recycling systems, energy-efficient LED lighting and a building management system.
The devises are important not only because of their construction skills, but even for what they host in the inside; they are the shelter of different types of technologies that allow three kind of experiences:

- Augmented reality, that allows the visualization of virtual elements in a real context, such as the Sila forest.
- Immersive reality, that allows the users to immerse themselves in a 3D virtual environment and interact with it.
- Interactive systems: that allows the creation of relationship between users and devices throw infrared systems that detect the presence of human body in the space, and trace his movement in real time.

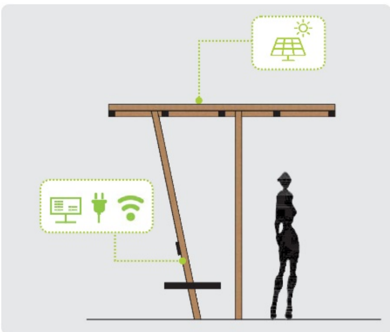

Fig.3: example of shelter-device

Fig.4: example of interactive totem

4 Conclusions and future perspectives

The proposed work shows the possibility of using the natural and cultural heritage as the main resource to attract tourist flows; to do this, we suggest a new strategy of valorization based on an immersive digital platform that helps the local economy to increase touristic flows in a sustainable way.
The platform is a geographic information system for tourism, whose operational logic is to create a highly interactive space with the users. The main results achieved by the creation of the ALforLab GIS platform include:

- attracting the tourist by offering diversified touristic paths;
- supporting the tourist by providing all information about local products, traditions, touristic attractors and accommodations;

DOI: https://doi.org/10.3217/978-3-85125-530-0-17

- tempting the tourist to visit identity landscapes, cultural, historical and natural heritage present in Calabria.

To achieve these goals we have created, within the test area, specific paths that users can select and query through the ALforLab platform using a smart device connected to the main server. These paths are of two types:

- identity paths, built on the basis of the identified identity characters;
- perceptive paths, that are the final result of the conducted perceptive survey.

In particular, once chosen the path, users will plan short and long stays, because they will find, within the platform, all the information about the destination, the type of the path and its travel time, the natural and cultural heritage on the territory (through hyperlinks), typical products, traditions or events, and special devices present on the paths. In fact, both routes are characterized by punctual elements, which perform various functions to: find shelter; have visible points for bus or shuttles stops; visit exhibitions outdoors; have at least one point for toilets, refreshment or relax; find along the path some info point or informative totems, have a bike sharing service and a cycle workshop; have the chance to enjoy of panoramic views; practice flora and fauna watching, or find picnic areas.

The goal for the future is to improve this network of paths, also including educational paths, in order to engage the educational sector on the theme of the protection and enhancement of natural and cultural heritage.

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Applying Mobile EEG to Measure Attention and Reading Time for Picture Books

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Abstract. People use the five senses to receive external information. These senses are used to communicate with the external world during reading development in children. Picture books with various types of sensory stimuli are frequently used as reading materials to help children learn effectively. The objective of this study is to examine various types of sensory stimuli of picture books, including visual perception (i.e. Conventional Book), and audial and visual perceptions (i.e. Talking Book). In addition, this study attempts to explore the relationship among attention, sensory stimuli and reading time of children with different ages. A mobile electroencephalography (EEG) device has been adopted in this experiment to analyze the correlation between attention and reading time of children who are reading various types of sensory stimuli of picture books. The result reveals that the students in lower grades exhibit spend a significantly longer time reading Conventional Book (visual sensory) than the students in upper grades do. Furthermore, age significantly influences attention and reading time in visual perception. Attention and reading time of the upper grades are significantly and positively correlated, indicating that the executive function of attention and reading ability improve with age. This study has provided a useful mechanism to examine the attention and sensory stimuli in reading that could be as a reference on how to improve the reading performance.

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Keywords: Children; Sensory stimuli; Attention; Reading time; Age; Picture book; EEG.

1 Introduction of Various types of Sensory Stimuli

People use the five senses to receive external information, and sensory information reception probably involving attention. The senses are used to communicate with the external world during early reading development in children. Various types of sensory stimuli help children construct a reading context, which enables children to learn independently (Holt, 2005). Tang and Posner (2009) indicate that sensory stimuli can change the physical and psychological responses of children, thereby enhancing their interest and attention.

Picture books often exhibit varying layouts and are published using various multimedia and textures to directly expose children to sensory stimuli, such as visual, acoustic, and tactile perception, thus facilitating children's reading (Briggs & Elkind, 1973; Ma & Wei, 2015). However, published picture books feature diverse forms of reading. Researchers should explore which sensory stimuli of picture book most effectively improve children's attention. In cognitive development theory, Piaget proposes that the development stages executive functions related to cognition and attention in children vary based on age (Bruner, 1996). Therefore, researchers also examine whether children with different ages demonstrate differing attention performance in response to picture books using various types of sensory stimuli.

According to Bednarek et al. (2004), children require longer time to read because of decreased abilities to focus their attention and inhibit distraction. Numerous scholars have indicated that ages differ in their attention span and state during reading (Buchholz & Aimola Davies, 2008; Van Petten et al.,2006; Wei & Ma, 2016). On the basis of the aforementioned literature, the relationship between attention and reading time of students in the lower grades and the upper grades will be further illustrated in this study.

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2 Visual and Acoustic Sensory Stimuli of Picture Books

In the area of product design, sensory dominance can be defined as the relative importance of different sensory modalities for product experience (Fenko et al., 2010). Therefore, in the current mature publication market, because of reader sensory requirements and improved multimedia technology, the content of picture books is presented through text, illustration, multimedia (e.g. various book materials, sounds, music, and animation), and diverse sensory stimuli and reading methods are used to attract children's attention and interests.

In this study, we select two types of sensory stimuli of the most common picture books in currently market, are (a) Conventional Book (visual perception), which is the most common book format and involves the simple behavior of page turning when visual reading; (b) Talking Book (acoustic and visual perceptions), which offers a multimedia presentation of the traditional storybook format, including the addition of speech feedback (e.g. CD and MP3 formats) so that children can elect to hear the story read to them (Wood et al., 2010).

3 Experimental Design: Tools and Participants

We use the mobile EEG device MindBand developed by NeuroSky as the experimental tool in this study. MindBand is a type of head-mounted EEG device that features a transducer installed at the position of the frontal lobe of the cerebral cortex to measure the α- and β-waves in the brain. The frontal lobe is the site of the attention network (Gevins et al., 1997). The advantages of MindBand are its light weight, compactness, stability, and ease of use. Therefore, it has attained considerably high acceptance among participants. In the attention EEG experiment, we collect the EEG data of the participants while they read the picture books. The data is ranged from 0 to 100 (0 being the lowest and 100 being the highest), enabling the collection of real-time information and analysis of EEG signals.

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In this study, we adopt the same story content but different sensory stimuli of picture books as the experimental tool for reading, namely, *Guess How Much I Love You* (McBratney, 2010). 24 children aged 8-9 years in the lower grades of elementary school students and 24 children aged 11-12 years in the upper grades of elementary school students are recruited as participants. Based on the experimental design, the participants at different ages are divided into two groups of reading picture books in two types of sensory stimuli: (a) visual perception: Conventional Book, and (b) acoustic and visual perception: Talking Book. The participants have not previously read the sample picture book.

4 Data Analysis

In this section, the data obtained from the EEG experiment of attention are statistically analyzed and discussed using descriptive statistics, One-way ANOVA, Independent Samples *t* Test, and Correlation Analysis. To examine the influence of age and sensory stimuli in attention, students are divided into four group: (1) visual perception: the lower grades, (2) visual perception: the upper grades, (3) acoustic and visual perception: the upper grades, and (4) acoustic and visual perception: the upper grades. Based on the average attention of each sensory group, children in the lower grades exhibit the highest performance in attention for Talking Book (52.92). By contrast, the students in upper grades exhibit favourable attention for Conventional Book (45.67). Moreover, regarding the performance of reading time, the lower grades spend a considerably longer time for reading Conventional Book than the upper grades (250.25 > 149.83).

4.1 Interaction of Age and Sensory Stimuli for Attention: One-Way ANOVA

One-way ANOVA is performed to analyze the relationships and differences of age and sensory stimuli in attention among the four groups. The result shows the lower grades and upper grades in groups to read picture books with varying sensory stimuli. The F

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value is 1.43 and *p* value is 0.24 (>0.05), indicating that there is no significant difference. It implies that children's attention does not differ significantly among the four group.

Table 1. Attention and reading time of students in the lower and upper grades

Source	Grades	Sensory	Mean	N
Attention (unit: 0-100)	Lower Grades	Visual (Conventional Book)	39.58	12
		Acoustic & Visual (Talking Book)	52.92	12
	Upper Grades	Visual (Conventional Book)	45.67	12
		Acoustic & Visual (Talking Book)	37.08	12
Reading Time (unit: second)	Lower Grades	Visual (Conventional Book)	250.25	12
	Upper Grades	Visual (Conventional Book)	149.83	12

(* The Reading Time for Talking Book is all the same because of the length of the audio track)

4.2 Age Difference based on Reading Time in Visual Perception: Independent Samples *t* Test

To further examine the influence of age difference on reading time in visual perception (Conventional Book), an independent samples *t* test is conducted in groups based on age. Table 2 shows that a significant difference (F=0.08, *p*= 0.00 < 0.05) is observed in reading time between the lower and upper grades. In addition, the *t* value is positive (*t* = 5.42), thus indicating the lower grades significantly spend longer time reading Conventional Book than the upper grades.

Table 2. Independent Samples Test for students in the lower and upper grades

Reading Time	F	t	df	Sig.	MD
	0.08	5.42	22	**0.00	100.42

DOI: https://doi.org/10.3217/978-3-85125-530-0-18

4.3 Correlation Analysis of Attention and Reading Time

Table 3 presents the correlation coefficient matrix of attention and reading time of the upper grades while reading Conventional Book (visual perception). Attention and reading time of the upper grades is significantly correlated (r= 0.73, p= 0.00 < 0.05), whereas that of the lower grades is not significantly correlated (r= -0.39, p= 0.081 > 0.05). Specifically, attention and reading time of the upper grades is highly positively correlated, indicating that the upper grades pay more attention to reading Conventional Book for a longer time.

Table 3. Correlation analysis of attention and reading time of the upper grades

		Attention	Reading time
Attention	Pearson Correlation	1	0.73**
	Sig. (2-tailed)		0.01
	N	12	12
Reading time	Pearson Correlation	0.73**	1
	Sig. (2-tailed)	0.01	
	N	12	12

5 Conclusion

This study has investigated that children with different ages demonstrate differing attention performance in response to picture books using various types of sensory stimuli, and also examine the relationship between attention and reading time. A mobile EEG device has been adopted in this experiment to analyze the correlation between attention and reading time of children who are reading various sensory stimuli of picture books. The results of this study are shown as follows:

1. When reading, children in the lower grades exhibit superior attention in acoustic and visual perception (i.e. Talking Book), whereas the upper grades exhibit favourable attention in visual perception (i.e. Conventional Book), although their attention does not differ statistically significant.

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2. The lower grades exhibit spend a significantly longer time reading Conventional Book (visual perception) than the upper grades do.
3. Attention and reading time of the upper grades are significantly and positively correlated, thus indicating that the executive function of attention and reading ability improve with age.

These results show students in the lower grades prefer Talking Book with acoustic and visual perception because young children may not have mature independent reading ability. Regarding the early reading experience of children, reading aloud, reading stories, and telling stories are indispensable processes for reading ability development in children (Dockett et al., 2006). Talking book with acoustic and visual perception is used to make picture books more interesting, and therefore, children can be attracted to the world constructed in picture books. In particular, young children have enhanced auditory comprehension ability that substantially surpasses their visual comprehension ability (Chall, 1996). Traditional paper picture books (Conventional Book) are the most common type of picture books, and these books are thin, light, portable, read at any time, and appropriate for readers of all ages. For children in the upper grades, Conventional Book constitutes a sequence of images with a narrative structure and brief text to convey stories and thus elicits the interests of children and attracts their attention, enabling them to focus on visual reading.

This study has provided a useful mechanism to examine the attention and reading performance. However, numerous factors affect attention and individual differences exist among children. In order to verify the experimental results, various important issues have to be investigated from different perspectives.

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Cultural Heritage Reconstruction Based on Virtual Reality Technology: A Pilot Study of Taiwanese Historical Sites

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Abstract. In recent years, Taiwanese railway culture has been increasingly valued. The trend toward cultural preservation further inspires the public and the government to preserve traditional railway culture. In terms of technology, virtual reality (VR), a system that allows users to interact, move, watch, and get immersed in a 3D environment, is gaining ground. It has been applied successfully in a wide range of fields. These successful applications have further become popular commercial products. In this light, we apply VR technology to reconstruct Taiwanese historical sites, the nonextant historic east Taiwan railway stations, to develop a VR simulation system which provides an interactive environment for users to experience and appreciate the east Taiwan old railway stations and railway culture.

1 Introduction

Trains have the advantage of having the largest capacity of all transport systems, whether for short- or long-range transportation. Many Taiwanese cities first began to develop in the areas around their railway stations due to the resultant concentration of people and vehicles (Chen et al, 2016). In addition, railway station localities are home to commercial activities which further drive development. As a result, the station is both the center of a city and its portal (Chien, 2013).

In recent years Taiwanese railway culture has been increasingly valued. The trend toward cultural preservation further inspires the public and the government to preserve traditional railway culture (Chen et al, 2016). As historic east Taiwan railway stations boast a meaningful, significant and historical background, the project "East Railway Overall Performance Improvement Construction", initiated in 2010 to renovate old railway stations, should follow the modern principle of preserving

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historical sites well (Chen et al, 2016; Chien, 2013). Although the buildings of the east Taiwan old railway stations are not delicately decorated, the public and the government should provide various options or alternatives that can connect and even evoke mass memories of Taiwanese railway culture (Taitung Railway Art Village, 2017; Yuliman, 2017).

Given that several historic east Taiwan railway stations no longer exist (as shown in Figure 1), it is a delicate task to render the appearance of these buildings to enable people to experience and appreciate them (Chen et al, 2016; Hualien County Cultural Affairs Bureau, 2017; Yuliman, 2017). The task also involves effective application of new technologies to this trend, which remains a critical issue and calls for more research attention. Virtual reality (VR) is a system that allows users to interact, move, watch, and get immersed in a 3D environment (Lawson et al., 2016). Therefore, in this pilot study, we apply VR technology to reconstruct the historical sites (i.e. the nonextant historic east Taiwan railway stations) to develop a VR simulation system which provides an interactive environment for users to experience and appreciate the east Taiwan old railway stations and railway culture through time (Chen et al, 2016).

Fig. 1. The nonextant historic east Taiwan railway stations (Hualien and Taitung)

2 History of East Taiwan Railway and Railway Stations

It was not until 1910 that the east Taiwan railway was built, after several official evaluations because of its forbidden terrain and mountainous environment, and lack of economic values (Hung, 2011). It started as a narrow-gauge railway (the width of 762 mm), in comparison with a standard gauge railway (the width of 1,435 mm) (Yuliman, 2017). With the operation of North-link Line between Suao and Hualien stations in 1980s, the railway connection resulted in population growth, industrial development and commercial activities in east Taiwan. The railway station not only is the center or portal of a city but presents the image of a city on which the urban planning is focused. As the urban planning changed, the Hualien old railway station was dismantled in 1992 (Hung, 2011). This dismantlement entailed the relocation of the city center and crowd to other areas. On the other hand, the South-link Line was operated in 1991, when the "Beinan" station was renamed to "Taitungsin". As the South-link Line increased capacity, the station saw a lack of hinterland, and the industrial structure started to change. In consequence, the Taitung old railway station was closed in 2001. It has become a historical site, and the "Taitungsin" station was

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formally renamed to "Taitung" (Taitung Railway Art Village, 2017).

These historical sites were once closely connected to people's life. While continuing to abide in their memory, they also offer rich cultural assets with splendid and magnificent scenery (Taitung Railway Art Village, 2017). How to work out a deliberate plan that combines urban development history, public activities, and cultural assets is a critical issue and a delicate task that calls for cooperation among Industry, Academia, and Government (Chen et al, 2016). Therefore, this pilot study attempts to pave the way for an interdisciplinary and cutting-edge cultural creation by applying a *new* technology (i.e. VR) to these *historical* sites to develop a VR simulation system.

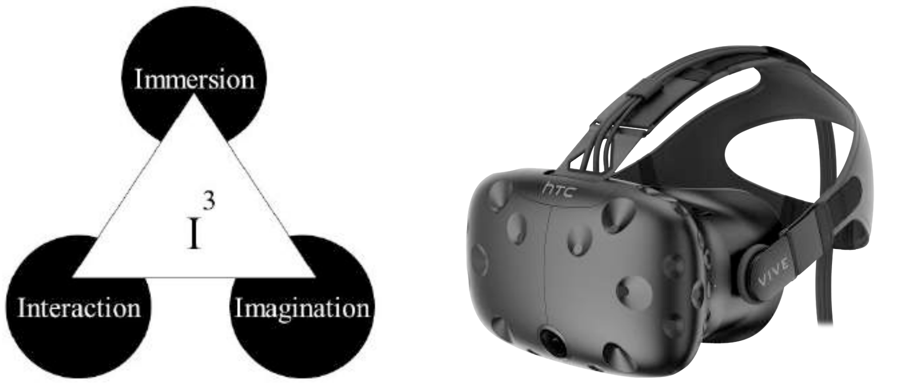
3 VR Technology for Cultural Heritage Reconstruction

VR has been applied successfully in a wide range of fields, including Digital Marketing, Online Games, Product Design, and Biomedical Engineering (Lawson et al., 2016; Putrino et al., 2015). However, a successful application of VR system has to comprise three principles, that is, Immersion-Interaction-Imagination, called 3I of VR or VR Triangle (as shown in Figure 2(a)) (Stappers et al., 2001).

(a) Immersion: the VR system can compellingly immerse users in the "virtual world" by utilizing high performance hardware, as shown in Figure 2(b), and inhibit users from being distracted by the real world around their surroundings.

(b) Interaction: the interaction component of this high-end user interface involves multiple sensorial channels, such as the visual, auditory, haptic, smell, and taste ones.

(c) Imagination: the capacity of users' mind to perceive nonexistent things and create the illusion.



(a) (b)

Fig. 2. The VR Triangle and the VR headset

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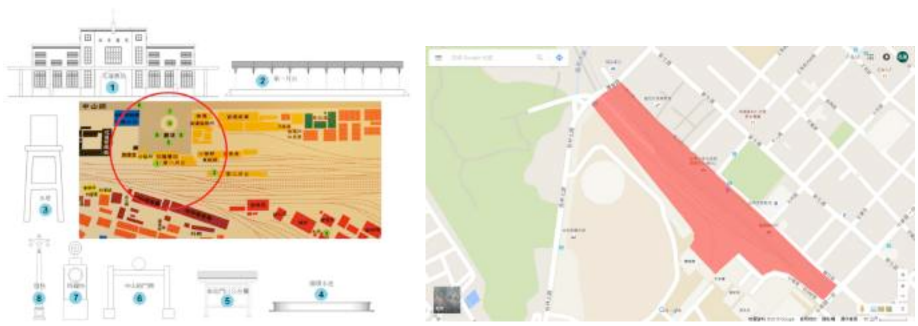
In addition, Milgram et al. (1994) first proposed the Reality-Virtuality (RV) continuum concept, which encompasses all possible variations and compositions of real and virtual objects (as shown in Figure 3). Figure 3 shows the Mixed Reality (MR) consisting of both augmented reality, where the virtual augments the real, and augmented virtuality, where the real augments the virtual (Reality-virtuality Continuum, 2016).

Fig. 3. The concept of Reality-Virtuality (RV) continuum

VR presentation in a cultural heritage application was first used in 1994 (Higgins et al., 1996), when a museum visitor interpretation system provided an interactive “walk-through” of a 3D reconstruction of Dudley Castle in England as it was in 1550 (Virtual Reality, 2010). Following in these footsteps, we show how VR technology can help develop a VR simulation system to reconstruct Taiwanese Cultural Heritage of the nonextant historic east Taiwan railway stations. The main procedure of the VR simulation system built in this study is shown as follows (Chen et al, 2016; Chien, 2013; Regenbrecht, 1997):

(a) Review the literature and relevant studies about the nonextant historic east Taiwan railway stations, and then form a focus group (including 5 experts) to define the boundary of the historic railway stations where the VR simulation system can be built, as shown in Figure 4 (Chien, 2013; Taitung Railway Art Village, 2017).



(a) Hualien railway station (b) Taitung railway station

Fig. 4. The boundary of the nonextant historic east Taiwan railway stations

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(b) Sketch the outline of the main buildings of the historic railway stations, and then build 3D models using 3D software, such as 3DS Max, Maya and Sketch Up, as shown in Figure 5 (Chen et al, 2016; Chien, 2013).

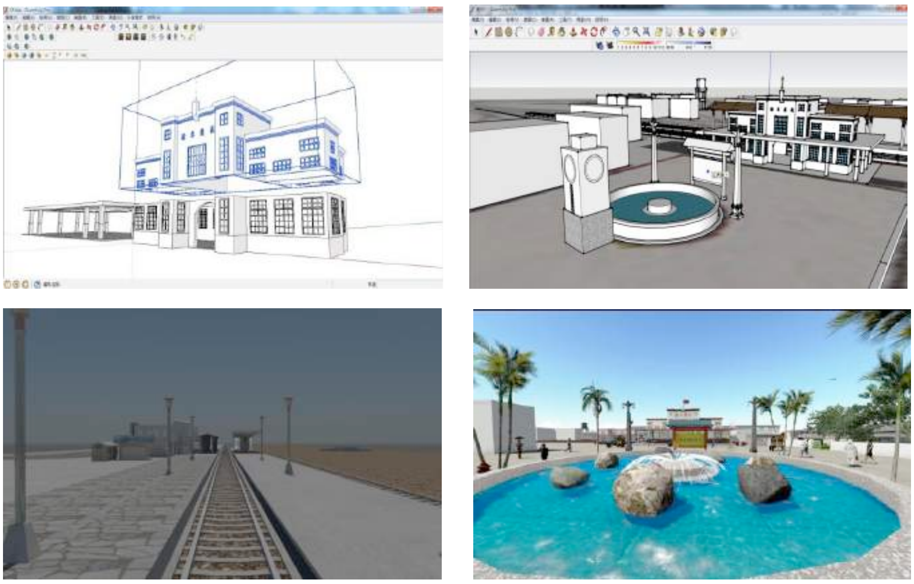

Fig. 5. 3D models built by 3DS Max, Maya and Sketch Up

(c) Render the 3D models using the Sketch Up, Lumion, 3DS Max, and Maya software, and then develop the VR simulation system by the Unity software, as shown in Figures 6 and 7 (Chien, 2013).

Fig. 6. 3D models built for importing to the VR simulation system

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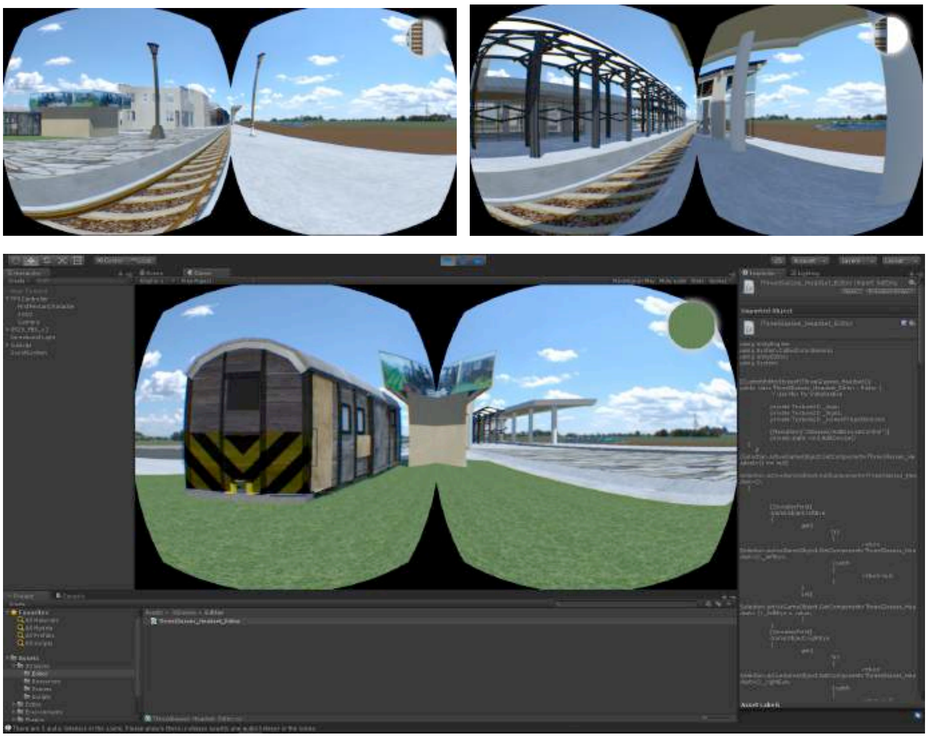

Fig. 7. The VR simulation system by the Unity software

4 Conclusion

We have applied VR technology to developing a VR simulation system to reconstruct the nonextant historic east Taiwan railway stations, i.e. the Hualien and Taitung old railway stations. The 3D software, such as 3DS Max, Maya and Sketch Up, are used to build and model the old railway stations, and the VR simulation system is developed with the Unity software. In this pilot study, we have incorporated the "new" VR technology with these "historical" sites. Effectively, the VR simulation system of the nonextant historic east Taiwan railway stations could connect and even evoke mass memories of Taiwanese railway culture.

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How to gamify the classroom?

A proposal for teachers training

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Abstract
Gamification can be challenging to implement, because it is not just to use game mechanics in non-game context. The first results reveal that it is necessary to focus attention on the design process, where some of the main problems were detected. The setback that occurred in the early years was due to the lack of knowledge and tools to enable it to be accomplished. Currently it is possible to find digital tools that help on the design of gamification. Also the knowledge available allows teachers to find creative solutions to successful experiences. It is in this context that a teacher training program has been developed that will enable them to structure and implement gamification in their classrooms. From the Octalysis framework, teachers will be able to decide about what emotions they want to provide to their students, and then structure what tools to use and which game mechanics to apply.

Keywords: Gamification; Engagement; Training; Gamification design; Octalysis framework.

1 Introduction

Gamification is a recent concept but its application is old. A good example is education itself that is organized by sequential levels, with feedback and progression. Only with mobile devices and the internet available now this concept appears and gain projection [1]. However the initial promise faded because of the difficulties they faced: on one hand, knowledge was poorly consolidated and on the other, the lack of specific tools [2]. In the last two years books have been published, digital tools have appeared and research has been made. So it is possible to be more close to uncovering how to gamify classrooms.

In this paper will be described the concept of gamification and the Octalysis framework. Based on that, a teacher's course was developed and is being implemented. For that reason it only be described what is programed to be implemented. The first results would be presented at the conference.

adfa, p. 1, 2011.

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2 What is gamification?

The new generations spend most of their free time playing on the most varied mobile devices available [3]–[6]. The technological development associated with the technical development of videogames and digital games created an environment advantageous to the emergence of gamification [1], [7], [8].

For this contributed the work of Jane McGonigal [4], a designer who saw in the games great possibilities to change behaviors or even the society. It is in the area of marketing and human resources management that this concept has been more applied, with Gardner, Inc. (consulting firm) forecasting its use by most companies by 2014 [1].

Deterding, Dixon, Khaled and Nacke [7] presented the first general definition: "Gamification is the use of game design elements in non-game contexts" (p.10). One of the authors in the area of gamification that has focused on its use in the area of education is Karl Kapp [1] who argues that "gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems" (p.12). Kapp distinguishes two types of gamification: (1st) the structural that corresponds to the application of game mechanisms to existing content and (2nd) the content where information, dynamics and content itself are changed through game design methods [9]. However, applying gaming mechanisms to any context does not mean that the desired effect is achieved. For example, the widespread use of badges we currently see is developing what Burke [2] calls a "badge fatigue" (p. 7), pushing away many of the users. It is important to direct the gamification to what the user will feel, because only then can we create engagement and achieve the desired effects [2], [10], [11].

According to Hamari, Koivisto and Sarsa [12], who evaluated the studies published in international journals, the education and learning are the most frequent context identified, and in these were pointed out positive results like increased motivation and engagement in activities, as well as fun. Points that need improvement were also pointed out, like the increase of competitiveness, the difficult to evaluate the activities and planning them.

At the Portugal national level, several projects have been developed; in the educational area, we find the application of methodologies in computer science [13], associating simulation games [14], implementation of the Openbadges mechanism in the SAPO Campus platform [15], a digital literacy project [16]. They are mainly situations of evaluation of the effects of platforms or digital tools that have characteristics of gamification in specific contexts, being based mainly on the use of badges, points and leaderboards. More recently, a proposal for a social stratification model for education, GET7, has been published, which outlines phases for the elaboration of a gamefull activity applied to education [17].

But most of these projects include development teams to create what teachers have planned. Unfortunately these conditions are difficult to provide in normal educational context because of the costs that are involved. This was why the idea to begin this project occurred. It is our aim to empower teachers to implement gamification with the tools already available under the schools conditions.

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3 How to apply Gamification on classroom?

According to Zichermann & Linder [8, p. 216] there are three reasons for gamification to be the future: (1st) "Gamification is the language of this new generation", (2nd) "The benefits of game apply equally well to older stakeholders", and (3rd) "Game delivers affordable, measurable, and scalable behavior change" (p.216).

Gamification is taking its first steps in the educational area, however that it is the context where more studies are published according to Hamari [12]. Most studies are based on projects where game mechanisms have been implemented in learning contexts [7], [12]. But Gamification is much more than that [1], its success depends on the interests of the recipients [2], [8], [10], [11]. One of the problems that has already been identified is the planning stage of gamification activities [12], which leads to poor design experiences that may have novelty effects, but without great relevance in long-term behavior change.

Robson [18] presents a framework of gamification named Mechanics, Dynamics, and Emotions (MDE). This framework was adapted from Hunicke, Leblanc and Zubek original game design: Mechanics, Dynamics, and Aesthetics (MDA). Aesthetics on the game design "describes the desirable emotional responses (…) evoked in players when they interact with the game" [21, p.413]. On his framework, Robson [18] replace 'aesthetics' by 'emotions' since it is a close term to engagement outcomes. MDE framework includes four components, namely:

- People involved -Designers, players, spectators, and observers.
- Mechanics - Decisions made by designers ("the goals, the rules, the setting, the context, the types of interactions, and the boundaries of the situation to be gamified" [18, p. 414]).
- Dynamics - behavior that emerges in players due to a gamified experience.
- Emotions - the emotional state and reactions that the experience provokes in the players - from this depends the extension of the player in the experience.

It is important to understand how these components can be organized to accomplish a successful gamification experience. What mechanics should be used? What is the relationship between Mechanics and Emotions? What can we expect from a set of mechanics? To understand how we can design and apply gamification it will be presented the Octalysis framework developed by Chou [11].

3.1 Octalysis Framework description

The Octalysis framework is based on the concept of Human-Focused Design that prompts that people have feelings, motivations, insecurities and reasons why they want to do something and optimize it to achieve that aim. All human actions have behind it a Core Drive that motives them. Octalysis [11] is an octagonal analysis of what drives anyone to do something, it describes eight core drives that explain the motivation that is stimulated by game mechanics (Table 1).

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Table 1. – Core Drive description on the Octalysis framework [11].

Core Drive	Description	Example of mechanics
1 - Epic meaning and calling	- it "is the Core Drive that is in play when a person believes they are doing something greater than themselves and/or were "chosen" to take that action" (p.25).	- Narrative - Elitism - Destiny child - CoCreator
2 - Development and accomplishment	- it "is our internal drive for making progress, developing skills, achieving mastery, and eventually overcoming challenges" (p.25).	- Points - Badges - Progress bar - Leaderboard
3 - Empowerment of creativity and feedback	- it "is expressed when users are engaged in a creative process where they repeatedly figure new things out and try different combinations" (p.26).	- Mission unlock - Instant feedback - Boosters - Choice perception
4 - Ownership and possession	- it "is where users are motivated because they feel like they own or control something" (p.26)	- Collection set - Avatar - Virtual goods
5 - Social influence and relatedness	- "incorporates all the social elements that motivate people, including: mentorship, social acceptance, social feedback, companionship, and even competition and envy" (p.27)	- Social treasure - Group quest - Bragging - Mentorship
6 - Scarcity and impatience	- it "is the Core Drive of wanting something simply because it is extremely rare, exclusive, or immediately unattainable" (p.27)	- Appointment dynamics - Fixed intervals - Count down - Patient feedback
7 - Unpredictability and curiosity	- it "is the Core Drive of constantly being engaged because you don't know what is going to happen next" (p.27)	- Mini quests - Easter eggs - Random rewards
8 - Loss and avoidance	"This Core Drive should come as no surprise - it's the motivation to avoid something negative from happening" (p.28).	- Progress lost - Evanescence opportunity -Fear of missing out

This entire Core Drives are organized in an octagonal shape being the 1 at the top corner and the 8 at the bottom, the even numbers are distributed on the left side and odd numbers on the right side. The Core Drives on the left side of the shape are more extrinsic motivation (logic brain side) and the ones on the right side are more intrinsic motivation (creative brain side), being the 1 and 8 core drives with the two sides. This octagonal shape also has positive (White hat) and negative (Black hat) drives. The top shape has the positive ones: they give us joy, and is possible to control them. The core

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drives in the bottom are the negative ones: they are urgent, addictive and we cannot control them. Chou [11] in his book presents more than a hundred mechanics that we can find in games and we can use them on gamification design. However, we must start by establishing what emotions we want the players/learners to feel on the gamification experience and after is possible to define the mechanics to use to achieve it.

The Octalysis framework explains how each mechanic affects players, allowing us to understand the motives behind their reactions. For this reason it was chosen to help teachers on the gamification design of classroom activities during the training.

3.2 A proposal to teachers training

"Taking quizzes and exams became 'defeating monsters', writing papers became 'crafting' and class presentation became 'quests'" [19, p. 424] is a way of easily explaining how teachers could apply gamification to their classrooms. But is necessary more than a change of words, we need digital tools easy to use and available to teachers and students. It is also necessary that all components (mechanics, dynamics and emotion) make sense to people involved [2], [11], [18].

Gamification requires digital tools to provide the full scope of a game and teachers can take advantage of the vast number of resources available through the Internet to achieve this. Thousands of digital tools and apps for mobile devices are available to be used, but it is difficult for teachers to keep up with developments and new releases.

These digital tools, if used properly, enable teachers to create engaging environments in their classrooms. An extensive list of digital tools has been collected and can be useful guide to teachers, but it is the context and how the tools are used that makes the experience engaging. Octalysis framework can lead teachers to choose which tools to use, how and at what time.

Training course for teachers is underway. It aims to uncovering the emotions that motivate students to learn and thought Octalysis framework, teachers will design and implement of a gamified activity in real context.

To design gamification experience for their students, teachers are invited to

1. Identify the goal they want to achieve (i.e.: change a behavior; engage students in a part of the subject;…)
2. Identify the emotions that can guide students to achieve that goal (i.e.: curiosity; item collection; peer appreciation; …)
3. Identify digital tools that could be used to reproduce these emotions (i.e.: online space to interact with students; different tools to create more interactive support materials)

Based on these choices, teachers will be supported by the project team to prepare and implement a gamification design they planned. The possibilities of combining the different tools are gigantic. This allows teachers to choose the options that best suit the technical conditions available in schools, the technical mastery they have over the tools and the interests of the students. Of course, it is not an easy task to do. We expect that the discussion of ideas between teachers and the sharing of experiences could have a great effect here. Also, the creativity of each teacher to think outside the box could have a big contribution to the success of each design.

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Presently this training is happening, for that reason is not possible to identify results. However, is possible to identify different type of digital tools that can be used. Table 2 is not exhaustive, but presents some of tools collected that appealed more teachers.

Table 2. Digital tools that can be used to design a gamifyed experience.

Type of tool	Description	Examples of digital tools
Platform to social interaction trough students and teachers	Online platform that allows exchanges between students, teachers and parents, where is possible to schedule tasks and give feedback.	Edmodo https://www.edmodo.com/ SAPO Campus http://campus.sapo.pt/
Gamification platform	Online platform that have gamification features ready to be used, like avatar, rewards, progress and achievements.	Class Dojo https://www.classdojo.com/ Class Craft https://www.classcraft.com/ LiveSchool http://whyliveschool.com Habitica https://habitica.com Blue Rabbit http://bluerabbit.io/
Collaboration tools	Tools that allow collaboration work between student and teacher. Facilitating the track and rapid feedback.	Drive (Google)
Exhibition tools	Tools that allow the creation of presentation more interactive to show in class. It can be used by students and teachers.	Amaze http://www.emaze.com/ Slidebean https://slidebean.com/ Prezy https://prezi.com
Exhibition tools with collaboration features	Allow to create a presentation and share it with students' thought their mobile devices and they can interact with it.	Nearpod http://www.nearpod.com/ ClassFlow https://classflow.com/ Pear Deck https://www.peardeck.com/
Quizzes	A set of questions to be answered, it can be used to assess students' knowledge or to help them to study.	Quizalize https://www.quizalize.com/ Quizizz https://quizizz.com/ Kahoot https://kahoot.it/ Plickers https://plickers.com/ Quizz Center http://quiz.center/en/
Quizz on text, image or video	Tools that allows integrated questions during the visualization of a video, in a PDF file or on an image.	ActivelyLearn http://www.activelylearn.com/ EDpuzzle https://edpuzzle.com/ Playposit https://www.playposit.com/ Thinglink http://www.thinglink.com/

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Video development	Tools that allow to create animated videos that can be used by teachers and/or students.	easelly http://www.easel.ly/ ToonDoo http://www.toondoo.com/ Screencast o Matic http://www.screencast-o-matic.com/ Go Animate http://goanimate.com/ My simple show https://mysimpleshow.com
Game tools	Tools that allow editing content in games, like crosswords, random picker, puzzle.	Jigsaw Planet http://www.jigsawplanet.com/ Educaplay https://en.educaplay.com/ Classtools http://www.classtools.net/

These tools will be useful to teachers to reproduce the mechanics necessary to increase the desired dynamics and observe the desired emotions happening. The important is to correctly combine all these tools. It takes a context that gives meaning to everything that is accomplished, either by the narrative that accompanies the unleashing of the tasks or by the challenge that was proposed to the class. It is up to the teacher to define the path that he considers most suitable for his students. This prevents possible technical limitations and technical competence that some tools may require.

4 Final Consideration

Who applies gamification has in common "the belief that human behavior can be changed through good, engaging design"[8, p. 220]. Also “Understanding the individuals that are involved in a gamified experience is fundamental to understanding gamification” [18, p. 414].

There is always a clear goal when gamification is implemented (examples: behavior change, understanding a subject, motivation for learning, etc...) however, must be adapted to the requirements that arise: technical conditions, mastery on the use of the tools chosen and the motivations that drive the ones involved in. Many variables can influence the execution of gamification projects; however, so far we observed that the sharing of experiences and cooperation between teachers are factors that have a positive influence in the execution of these projects.

It is our intention to present in the future the results obtained through the training of the first group of teachers and later improve it, so it would be possible to teacher to gamify their classrooms with success.

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p. 8

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Integrating Wearable Technologies and Sport Analytics for Personalized Immersive Training and Learning

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Abstract Wearable technology, wearable computers and electronics, possess a significant role in sport analytics. The Immersive Learning Research domain gets excellent insights from the integration of wearable technologies in the sports domain. Personalized Training of Athletes and design of active learning scenarios for professional athletes and amateurs, based on Wearable and Mobile Analytics is an emerging domain of research with great potential. The purpose of this research paper is to provide an overview of Wearable Technology, how it started, how it is used up to nowadays and to elaborate critically with the state of usefulness of wearable technologies in sport analytics. The main contribution of this research work is a methodological framework for the exploitation of Sports Analytics for Advanced Decision Making. The provision of a research model integrated with a general architecture for an Open Cloud Service aiming to provide advances Analytics services sets the milestones for the launch of a relevant prototype.

1. Wearable technologies as a critical domain of Immersive Learning Environments Research.

The study of Wearable Technologies can be performed in relevance to many different scientific domains. The integration though of this technology in the Sports domain is still in early stages with many unexploited opportunities. The purpose of this limited literature review section is to highlight that the next wave of significant contributions in the domain will integrate some or all the following aspects of advanced information systems and information technology integration:

- Systematic profiling of athletes and non-professional profiles for sport activities. The standardization of various complementary tacit and explicit elements of knowledge related to sport activities is critical
- Integrated annotation of sport activities with metadata standards available for general and special purposes.

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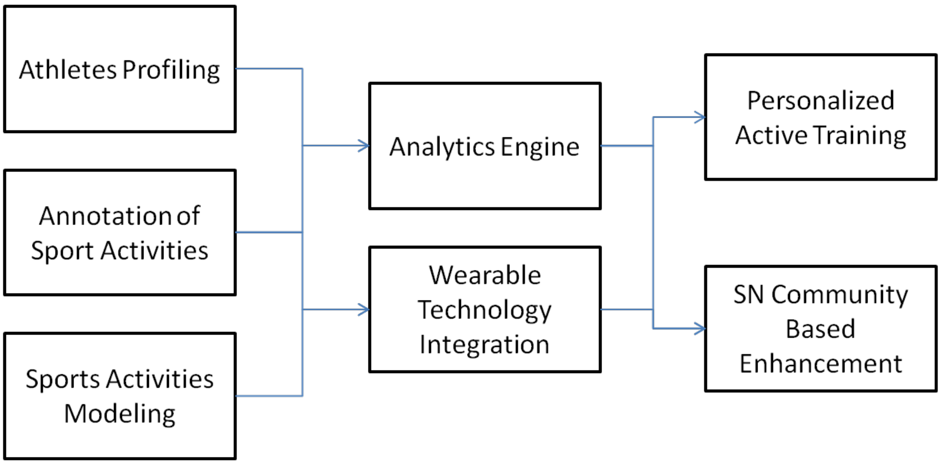
- Sophisticated design of interactivity scenarios for active learning and a-posteriori enhancement through monitoring of actual performance, and analytics
- Integration of Immersive Techniques for Sports Training.
- Design of a cloud infrastructure for the open sharing of resources related to sports analytics and personalized training programs.
- Implementation of a self-sustained social network for the provision, creation and consumption of Wearable Data and Analytics

The research problem we try to address in this research study is related to the integration of the above areas as follows:

How can we implement a flexible, open, Immersive Environment in which personalized training and learning will be enabled by the integration of distributed data related to sport activities? The detailed analysis of requirements for the codification of sport activities and human entities and the detailed analysis of use cases scenarios are the first steps towards the development of an Open Cloud Immersive platform for the provision of advanced Sports Analytics enabled by wearable technology interactions. In figure 1, below, we provide a first abstract overview of the research context and vision of this study.

Figure 1. The Integration of Wearable Technology and Advanced Sports Analytics for Social Enhanced Personalized Active Training.



Wearable technology refers to the electronic parts or devices that can be worn by someone and require no hands use. Per McCann & Bryson (2009) "*A true piece of wearables electronics is also required to be worn to function, i.e. conceptually linked to the wearer's body*". The first attempt to implement wearable technology has been made by the military during the cold war, mostly with GPS tracking systems, mines detecting systems or explosive systems that were attached on soldier's clothes. With

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the evolution of the WWW, in the 1990s people did not only have access to wearable components but also, they had the ability to use web based services for the tracking, storing, and use of data in wearable scenarios. The exploitation of wearables in the sports domain is an evolving process. The latest developments in Sensor Networks, in Distributed Information Systems, and in Wearable Technology and Virtual Reality, offer the opportunity for ubiquitous and pervasive immersive learning networks. The Sports domain is in the focus of our research. As Bernard Marr (2015) states, "*Smart technology is now widely used in sport to find and recruit talent as well as monitor and improve performance – both for the amateur and the professional*" and wearable technologies and analytics are frequently used in every day's life to increase his/her health condition.

In addition, wearable technologies in sport analytics played a significant role the last decade for the support of decision making process. In the next section, we analyze the critical role of knowledge management for the justification of Sports Analytics as a Knowledge Management case for Advanced Decision Making.

2. An integrated Knowledge management consideration of wearable technology in sports

Nowadays, there are many initiatives related to advanced decision making in sport analytics. Athletics, football, basketball and especially baseball teams from all over the world are trying to implement innovative ideas and to invest to make an effective use of wearable technology. Our research is a knowledge management primer. In fact, we recognize that several critical knowledge elements are necessary for the creation of a Sports Analytics Ecosystem through wearable technologies. As reported by Koenig (2012) "*The origin of KM, as the term is understood today, arose within the consulting community and from there the principles of KM were rather rapidly spread*". Per Duhon (1998), "*Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers*". Knowledge management systems, are frequently used by large organizations – corporations, because they have realized their importance in terms of transferring, sharing and managing information and knowledge.

As Hahn and Subramani (2000) and Davenport (1998) discussed, "K*nowledge Management Systems (KMS) are tools to affect the management of knowledge and are manifested in a variety of implementations*". The legendary work of Nonaka, on knowledge creation, and his proposition of the SECI model, which is essentially a theory that describes the conversions between the two types of knowledge, tacit and explicit, has an impact in our research study. Based on Nonaka's propositions we are looking for wearable generated data transformations related to the four significant knowledge creation processes namely, Socialization, Internalization, Externalization and Combination. This objective links the process on answering the question of how

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the analytical data taken from wearable components are translated into meanings and insights for a regular user or a professional analyst of Sports Analytics, e.g. athletes, trainers etc.

This kind of "translation - conversion" can be called knowledge creation where according to Jantarajaturapath et al, (2016) "*Knowledge creation is activities for developing new content or replacing existing content within the interactions of tacit and explicit knowledge*". Following Nonaka's theory about the two types of knowledge it should be mentioned that tacit knowledge is the knowledge a person can have from its experiences, ideas ore emotions, and explicit knowledge as reported by Nonaka (2000) "*can be expressed in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals and such like*". A key question related to our research is the detailed analysis of tacit and explicit knowledge components that are required for the detailed profiling of Sports people. This is critical not only for an ontological approach to the specification of related semantics for the enrichments of data but also for the understanding of the key use cases and scenarios for the exploitation of data insights for decision making. From an immersive point of view, the detailed analysis of these critical data derived from wearable technologies can enhance several immersive virtual reality stories.

The convergence of Data Science and Knowledge Management in the Sports Management domain is very interesting. The human actors in the context of sports activities define a variety of knowledge flows, while several critical decisions are associated. Several Editions discuss in details the role of Analytics in Sports and their critical influence in the sports industry. A significant aspect of our research is related with the detailed analysis of requirements for the use of analytics in the sports industry. For this purpose, we plan to run an international survey aiming to codify and to map the variety of different types of analytics.

The legendary work of Nonaka (2000) *on SECI, Ba, and Leadership: A unified model for dynamic knowledge creation,* has a significant implication for our research study. The definition of immersive Ba for the provision of Active Training sessions in the sports industry needs a further investigation. The ideas of Nonaka for Tacit knowledge are linked with mental and psychomotor abilities of athletes and nonprofessional trainees. A first interpretation of the way that big organizations manage knowledge, is a model for knowledge creation which explains extensively the ways knowledge (tacit or explicit) is converted. In our work this metaphor help us connect the internalization process of the SECI model with our research in how sport data analytics are being analyzed by experts and how they are transformed in to performance.

The integration of wearable electronics and sensors in our days provide a very wide range of applied scenarios for the Sports Industry. In the work of Howcroft (2016) a systematic discussion of such a classification model is provided with implication for our research. It is an aim of our study to investigate which are the use case scenarios

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for the provision of meaningful active learning sessions to athletes powered by systematic analysis of wearable analytics.

The above discussion becomes more complex if we add in to the perspective the role of Big Data. Many scientific works in various domains discuss the efficiency of Smart Big Data, Analytics and Metrics to Make Better Decisions and Improve Performance. This is rather the ultimate objective of our research. To provide a prototype system capable of managing Smart Big Data and Analytics and Metrics for the Sports domain.

In our research, it is understood that the data that are retrieved from the wearable devices are results of explicit knowledge since they are numbers, statistics, and formulas. However, the person who will have the task to translate these data into actions and advanced decision making and give them a meaning must have the tacit knowledge to do that. For example, if an athlete has a high heart rate, only a doctor can understand what this athlete needs to do to decrease his heart rate during a specific exercise so he will not harm himself. Another example is, when an analyst sees an athlete who covers pointless meters into the pitch only he/she and the coach can tell him/her that he/she is doing pointless moves and to focus his/her game in another area. The detailed specification of these kind of data is an ongoing objective for our research. The detailed mapping of explicit and tacit knowledge attributes to sport activities is a time-consuming process that requires the involvement of the community from different scientific domains. Nowadays and for our study the data population and metadata annotation of sport activities seems to be a complicated phenomenon since with social networks and wearable technology integration we can realize unforeseen before data flows. Table 1, below, contains some examples of the conversion from explicit to tacit knowledge in data sports analytics:

Table 1. Tacit and Explicit Knowledge Attributes in Sports Analytics

TYPES OF KNOWLEDGE THROUGH WEARABLES FOR SPORTS	
Explicit	Tacit (and Analytics Scenario)
Heart Rate	Check for how many minutes this player can play without hurt himself, and prepare the best training program for him
Dynamic Stress Load	Check under what circumstances this player plays better
Max. Speed – Acceleration – Deceleration	Check in which position this player would be more productive, and provide him/her with a nutrition program to increase his/her stats
Distance Covered	Check how many meters can a player cover into a game
GPS Tracking	Check in which part of the field the player contributes the most

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Training profiles	Systematic analysis of most effective scenarios
Immersive Data	Which is a feasible learning environment for the integration of actions into an aposteriori adjustment of training practice

The above table is indicative. Several other more complex decisions can be supported in an end-to-end ecosystem of Wearable Sports Data Analytics.

Consider for example the following cases:

- How the know-how of advanced trainers can be integrated to personalized training plans of individuals, adopting collaborative filtering approaches? How this can modify significantly the mental models of trainees (Socialization)?
- How can the explicit knowledge sports data can be integrated in an advanced model (combination) which can be used as a basis for advanced decision making?
- How the four knowledge creation processes can serve as value carriers in group training?
- Which are the basic scenarios for the consumption of Big Data generated in Sports Analytics ecosystem?
- How sportsmen can promote synergetic approaches for socialization and advanced sports training?
- How a knowledge repository powered by advanced distributed data infrastructures e.g. lie Hadoop can be implemented?
- Is it possible to provide an Open Cloud Eco System for the creation and the consumption of sport data oriented applications?
- How immersive research can provide new motivating and engaging scenarios for active learning?

This list is not exhaustive for sure. In a journal publication, we intend to present some interesting findings. From the aspect of the Analytics methods it is true that the variety of industrial solutions like SAS.com or Tableau, can provide a collection of applicable data mining methods. It is though much more demanding the specification for a prototype capable of managing wearable and mobile sports analytics. Because of the above considerations, the emphasis of this research work is on advanced data mining methods in sports analytics, and it is linked directly to the internalization process of Nonaka's SECI model since explicit knowledge is converted into tacit. In the next section, we provide the main aspects of our research model.

3. An integrated Research Model for the Study of Sports Analytics in Immersive Learning Environments.

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The research model in our study is organized around two significant research questions:

Research Question 1: *Can the Wearable Technology and Sensor Networks technology be successfully applied in the sports domain, be available in amateurs and increase the effective knowledge management of its users? And is it worthy for the teams to start invest in the sport data analytics domain, instead of wasting huge amounts in non-value adding activities?*

First of all, wearable technology can be successfully applied in sports' domain, due to the fact that it is an improved and an already applied technology and as Howcroft (2016) notes in her research article, "Wearable-sensor based models were able to predict retrospective fall occurrence in individuals and outperform the predictive ability of models", since wearable sensors have such capabilities why they cannot be used to improve the performance of an athlete? Not only it can improve his/her performance but also it can prevent him/her from possible injuries. Moreover, this technology has been improved so much that its cost is not big and it has been available for amateurs through mobile phones and watches that can measure the heart rate, the distance someone walked or even provide the person with a training program per its characteristics (how many times per week he/she exercises, weight, height, nutrition habits). Thus, it can be easily observed that not only this technology can be applied in sports, for professionals and amateurs, but also it needs to be part of our life if we want to improve our health habits. This statement provides also the motivation of our study.

Research question 2: *Which are the critical requirements that must be integrated in a real world open, cloud, flexible, ecosystem of shared Sports Analytics?*

This research question is directly linked to the interpretation of SECI model and its integration with advanced Data Science and Big Data propositions. For each of the knowledge creation processes several Use Cases Scenarios for distributed shared Sports Analytics can be defined in relation to Sport Activities. A detailed

Davenport (2014) states "even relatively wealthy teams cannot afford large investments in technology, data, and analytical tools". One thing that needs to be mentioned in this part, is that data analysis is a science and it needs people with specific skills to make this science applicable in an industry and sport data analysis is a domain that needs both sport and data analysis experts, who will be able to combine their tacit knowledge and conclude to a profitable result for an organization. As correctly O'Donoghue and Holmes mention in their book "Data analysis applied to sports performance data include statistical analysis, temporal, analysis, artificial neural networks, simulation and data mining" so a combination of three sciences has to take place in order to make an effective use of sport data analysis. Taking under consideration the research of Davenport (2014) "It's impossible to equate winning records with more analytical capability, but the recent success of highly analytical teams—the Boston Red Sox and New England Patriots, the San Francisco Giants and 49ers, the Dallas Mavericks and

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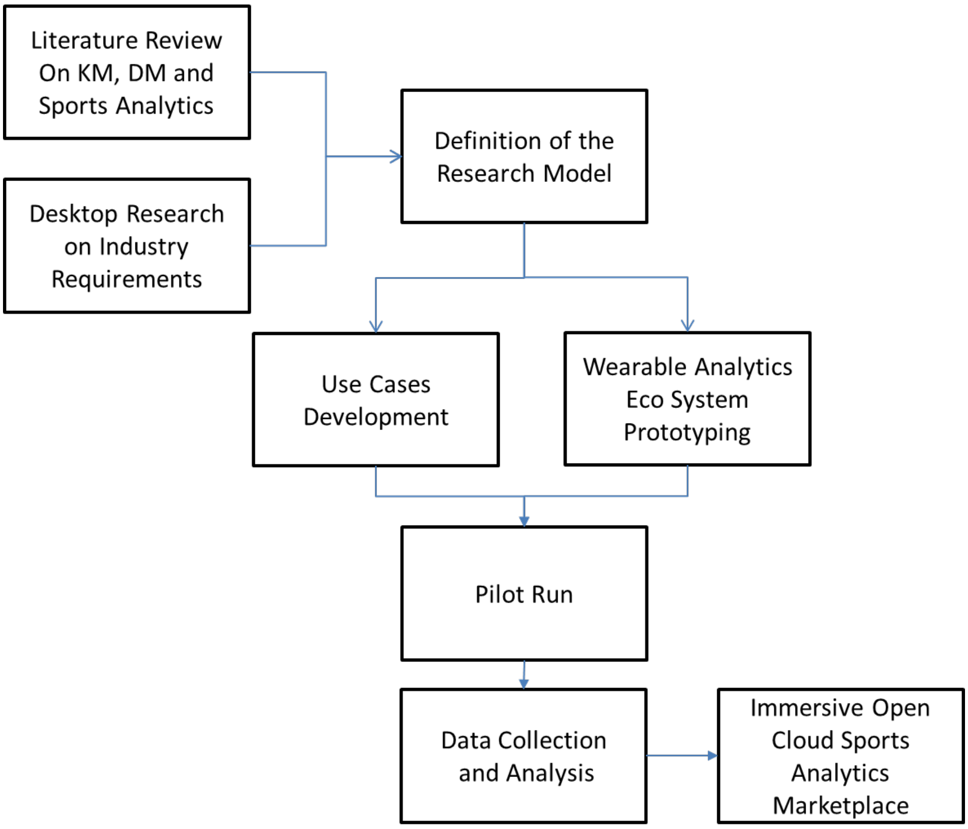
San Antonio Spurs—suggests an important role" it is easily observed that analytics can make a contribution in the sport domain and if the teams invest more on this, it is sure that they are going to improve their results not only in terms of players' performance but also in terms of money. They may need to increase the cost to hire data analysts but they will stop pay big contracts to players who have been hired without any research and they proved to be failures, and the number of injuries would be much smaller during a year using a sport doctor analyst. It is well known, that a science like mathematics can never fail.

Figure 2. The Research Methodology of our Study



In figure 2, we provide our ongoing research methodology with a target to launch the first prototype very shortly. The overall idea is that the integration of theory with detailed structured desktop research has resulted to our research model that investigates the integration of sports analytics in the provision of immersive learning scenarios for athletes and people who are practicing. In the current stage we are elaborating on the basic use cases for the prototype and we are considering a number of scenarios

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organized around SECI model. In the next section we provide the basic technical aspects and the main business requirements for the intended system.

4. A prototype architecture for an advanced Open Cloud Distributed Agora of Sports Analytics

The detailed study of literature and the intervention with several initiatives in the areas of Big Data, Analytics in Business and in Learning, have resulted to critical requirements for a new eco system of Sports Analytics towards the provision of personalized and community enhanced Learning Experiences. As discussed in previous section the basic idea is that Wearable technology will be used as the main enabled of a variety of Sports Big Data, and then a sophisticated system will analyze, transform and enable services capitalizing on the value of Analytics.

The best electronic component - tool that is mostly used in sport data analytics, is a little GPS tracking system, which has more abilities than a simple GPS. This device is used by the best teams which participate in the biggest leagues in the world such as Premier League, La Liga, NFL and NBA. It is inserted under the clothes of athletes and it is strongly held by a vest or base layer close to their chest or their back. Its size is approximately 30mm width and 90 mm height, and weight less than 50 grams, very small and light. As it is easily understood, we are talking about a revolutionary product and the peak of internet of things. This electronic component contains an accelerometer, GPS module, gyroscope, digital compass, and heart rate receiver. What all these features are capable of? Firstly, we must mention that the output of this device is in a computer and it cannot be reviewed by only one person, it provides results that a doctor, a psychologist, a coach or a data analyst must read. For example, by checking an athlete's heart rate for the entire game, it gives the possibility to the coaching staff to know not only the feelings of the athlete but also his/her level of tiring. With the accelerometer, an athlete's stats can be checked like speed and acceleration. And one of the most important functionalities of this device is that it can track an athlete's position in a field. With the compass, the gyroscope and GPS module the analysts can check which part of the field this player like to move more and in which period of the game. Moreover, they can check if, in situations with high pressure, he/she can still keep his position or if he/she is running for no reason when he/she feels angry. This electronic pod is most probably the best technological tool that is used in sport data analytics since it provides all the results that a coaching team would need to know about a player. Our analysis for the value contribution of our research is provided in the overview of an under construction prototype system for Immersive Learning Experiences.

5. Proposed Prototype

The proposed prototype of our research is based on an input device / collector consisted of a wearable bracelet which functions in the almost the same way as the device that has been described above. The difference is that this bracelet will be worn in the hand

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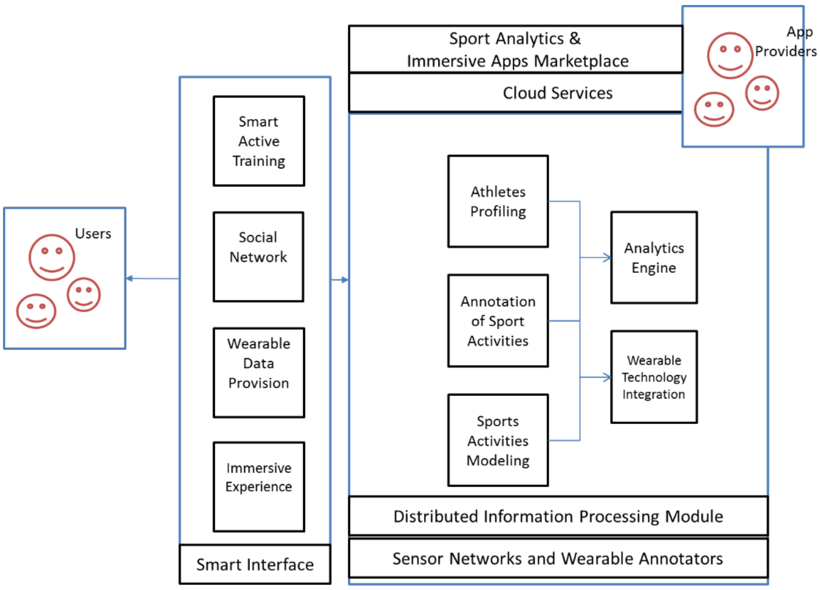
of the athlete so he will not have to carry a device on his chest or back which could cause an injury in a serious tackle. Also, this device is going to be much lighter and will be rubber band to avoid any possible injury of the athlete who wears the device or his opponents.

Regarding the technical part, this bracelet will be able to be calibrated by the preferences of each user so he/she can compare the results based on their personal singularities and not an average person's ones. In addition, the device will run with android software which means that the user will be able to completely modify the interface of the software used, the timers, the alarms or the sounds of the device.

Moreover, for the implementation of the first prototype some hardware and software will be needed except from the bracelet, a server and a database.

Figure 3. The Proposed Prototype Architecture and Requirements Model



In figure 3, we present the basic modules of the proposed Architecture with a 3-tier approach. The basic Systems are presented briefly below:

- ***The Smart Interface***: Provides the main modes for interaction with the systems from a variety of users, including athletes, nonprofessionals, and community groups. The basic components capable of calibrating are the Wearable Data Provider, the Social Network Collaborative Enhancer, the Immersive Experience Module and the Smart Active Training and Learning Wizard. Through these systems users can design a personalized Learning Experience

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- ***The Sports Analytics Ecosystem***: It is the main component of the architecture and has four basic modules. The Sensor Networks and Wearable Annotator that is attaching a number of metadata to all the Wearable data based on specific considerations of Sports Activities and Performance from different scientific perspectives. The Distributed Information Processing module that enables the integration of Big Data from users community. The main module is related to the Analytical Capability of the system. The athletes and users profiling module together with the Annotator of Sport Activities and the Modeler of Sports Activities and Use Scenarios provide the parameterization of the system. The Analytics Engine permits a variety of Data Mining Methods and enables advanced decision making. The Wearable Technology Integrator is in fact an Immersive component that allows the evolution of different wearable technologies and sensors. At the top of this architecture that sets the business requirements systems, we have the design of various cloud services and a marketplace of wearable analytics applications. In fact our prototype serves as an agora of advanced sports analytics services and applications that serve as value integrators.

6. Conclusion

It is fully observable that wearable technology can have a very important role in the sports domain and maybe in the next years, big sport organizations will focus more on this science. In this research paper is presented, an overview of this technology, the way it can affect the decision making process of an organization and how it can improve the management of knowledge in sport teams in order to produce better and more profitable results. It needs to be said, that this is only the beginning, the first attempt to enhance wearable technology in sports but there is a lot of time and space for future research to make new things and to improve new technologies. A possible scenario – idea for future research would be, instead of making the athlete to carry a device on him, it would be better to enhance this technology in the fabric, this would be revolutionary. To sum up, big sport organizations must implement technologies like this if they want to increase their efficiency and amateur athletes should follow such technological achievements in order to protect themselves, keep track of their heart condition and have a more effective and healthy exercise.

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Immersive Learning of Biomolecules

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Abstract

This paper reports a new international initiative on the use of virtual and augmented reality (VAR) technology to assist student learning of biomolecules. Researchers, developers and educators from Nanyang Technological University, National Institute of Education, Hwa Chong Institution and River Valley High School in Singapore, Utrecht University and Windesheim University of Applied Science in The Netherlands, will work together for two years on this project. The objective of this research is to investigate the benefits of applying the latest VAR technology to enhance students' learning of molecular biology. In particular, the project is keen to design new immersive and interactive contents for selected topics such as enzymes, proteins, DNAs etc., in molecular biology. This interdisciplinary collaboration has a potential to grow globally.

Key words: Virtual & Augmented Reality • Technology Enhanced Learning

1. Introduction

Science education aims to build students' skills and attitudes towards Science, Technology, Engineering, and Mathematics (STEM). In STEM, the learning issue can be defined at two levels. At a generic level, students need to learn about the nature of scientific knowledge and the role of models as representation of that knowledge in particular. Within the specific domain, e.g. molecular and cell biology that will be studied in this project, the relation between models and reality is particularly apparent. It is important that students gain insight in both the explanatory powers of models and their limitations in understanding in this domain, and learn to see the added value of using multiple representations and multiple models. The construction and evaluation of scientific models (Lohner, van Joolingen, Savelsbergh, & van Hout-Wolters, 2005; Minner, Levy, & Century, 2010) provide a means to offer students experience with scientific research. Several modelling tools (Blikstein, Abrahamson, & Wilensky, 2005; Louca & Zacharia, 2011) have been developed to enhance and stimulate deeper learning. Virtual Reality (VR) is widely considered as one of the most viable applications for use in education (Freina & Ott, 2015; Merchant et al, 2014). These tools allow for the creation of task environments in which realistic and authentic forms

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of inquiry are possible and within the reach of students in secondary education. The benefit of such a realistic context can be linked to the potential of technology to make students' learning experiences more authentic and vivid, and to increase exposure and interaction. Authenticity is considered important, because more authentic learning experiences may lead to higher cognitive fidelity, which in turn could contribute to better learning outcomes.

Over the years, we have developed innovative technologies including Virtual & Augmented Reality (VAR), Simulation and Serious Games to enhance learning (Cai, Tay & Ngo, 2013; Tan & Waugh, 2013; Chow & So, 2012; Cai & Goei, 2013; Cai, Goei, & Trooster, 2016; Rutten et al., 2012; van Joolingen & de Jong, 2003; Cai, 2011 & 2013; Cai et al, 2006; van Joolingen, de Jong, Lazonder, Savelsbergh, & Manlove, 2005).

This paper presents an international effort to develop and evaluate the efficacy of VAR technology to enhance secondary school students' learning of molecular biology. Researchers, developers, and educators from Singapore and The Netherlands tie up through this international collaboration. The research outlined is an attempt to bring together educators, researchers, teachers, and students using a cross-cultural partnership not only to develop effective and validated pedagogies for inquiry-based learning, but also to model and stimulate skills and attitudes in our students and student teachers that are relevant for functioning in highly complex and fast-changing 21st century working environments, in which professional teams need to collaborate, cross boundaries in activity systems, and develop and speak a common professional language. The VAR technology to be developed aims to create immersive learning environments for students to better understand bio-molecules through VAR interaction.

2. The Focus

This research focuses on Molecular Biology. Presently, textbooks typically depict molecular and cellular processes such as enzyme operation and protein synthesis with iconic representations of specific molecules, illustrated to highlight a simplistic generic mechanism that students must learn. Despite this representation useful to obtain a view of the processes, there are aspects that are not covered, but important for understanding the essence of the processes involved. For example, apart from the 'lock and key' idea of an enzyme for molecules to 'snap' into each other, the molecules themselves are dynamic structures and their movement within the cells adds to the dynamic. Whereas the textbook representation may give rise to the misconception that molecules display purposeful behavior, a representation that incorporates dynamics can give rise to a more accurate 'mechanistic way' of reasoning that is capable of explaining the effects of external factors such as temperature and pH value in the cell. The project aims to develop models and modeling environments in which students can create and play with such multiple representations, as well as lesson plans to support learning in these environments. In this way students can learn concepts, processes, and functions within the domain of molecular biology and

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develop 21st century competencies related to the understanding of science and scientific knowledge.

3. Lesson Study

Lesson study is a collaboration-based teacher professional development approach that originated in Japan (Fernandez & Yoshida, 2004). In this approach, teachers collaboratively engage in research inside their classrooms using a design cycle: prepare and design lessons, perform the designed lesson as a research lesson and evaluate them in order to feed into the next cycle (Cerbin, 2011). Teachers collaboratively design one or more research lessons in which they attempt to adjust to the varying educational and instructional needs of their students (Goei, 2013). Great thought is devoted to predicting how students may react. Importance in the Lesson Study cycle is that teachers as Lesson Study team members observe the students when the research lesson is enacted in the classroom, and have special attention to the learning activities and behaviors undertaken by the students. Immediately after the lesson, it is evaluated with the focus on the learning activity, rather than on the performance by the teacher who executed the lesson (Becker, Ghenciu, Horak, & Schroeder, 2008; Oshimaa, Horinoa, Oshimab, Yamamotoc, Inagakid, Takenakae, Yamaguchif, Murayamaa, & Nakayamaf, 2006). Observations are shared, ways of refining and improving are discussed and the subsequent review of the lesson is planned. In the design, implementation, and evaluation of the modelling activities, teachers will be actively involved using Lesson Study (Lewis, Perry, & Murata, 2006).

4. VAR Technology Enhanced Learning

Over the past 10 years, the Singapore team has been developing VAR technology for educational use. Figure 1 shows students from River Valley High School engaged in interactive learning of Biology in their daVinci VR Lab.

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Fig. 1: Students from River Valley High School doing interactive learning of biology in their daVinci VR Lab

The VAR enabled solutions will be designed by the Singapore team specializing in immersive and interactive education technology (Cai, 2013) in collaboration with the Dutch team emphasizing on sketching and drawing (Bollen & Van Joolingen, 2013). The pedagogy will be jointly developed by the Singapore and Dutch teams based on Inquiry-based Learning and Modelling. The novelty of the development is in the intersection of general concepts of models in multiple levels with multiple variables for teaching and learning. These variables will be limited to temperature and pH in a simplified setting, and become generalized possible later. The models include simulation and 2D/3D visualizations. Researchers, developers, teachers, and teacher educators from both Singapore and the Netherlands will work together to create the content. The validation of the designed pedagogies and lesson plans will be done via the Lesson Study method.

Figure 2 shows the initial design of interactive and immersive learning of macromolecules using the daVinci VR Lab available at Hwa Chong Institution.

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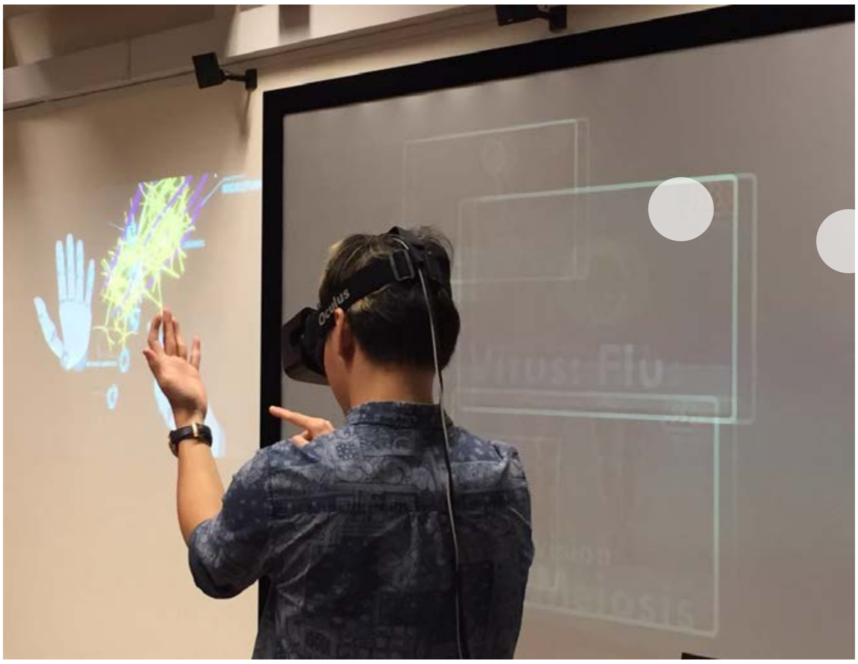

Fig. 2: VAR Technology Enhanced Learning of biomolecules in the daVinci VR Lab at Hwa Chong Institution

4. Conclusion

This project has the timeliness to explore the application of VAR technology in education, especially STEM education, aiming to help students better understand scientific concepts through model-based simulation for interactive learning. With the VAR tool, it may be possible to allow students to try self-engineering a *de vova* enzyme and validate the effectiveness of the virtually engineered enzyme using the models and VAR tools developed. Last but not least, one of the existing challenges for higher education is to internationalize its programs and to make students more globally competent. Although teaching is often tailored to local contexts, international collaboration can be important for educators as they grow professionally through exposure to innovative ideas and best practices in other settings. It may be expected that in the two countries, teaching traditions, learner and teacher dispositions are different, providing teachers on both sides of the collaboration with fresh insights. These insights and viewpoints will add to the depth of which VR lessons are created for student learning.

Acknowledgment

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Adopting Game Technology for Heritage Information Modelling

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Abstract. Contemporary Building Information Modelling (BIM) has had a huge impact on the design, construction and management of modern buildings – enabling improvements across a wide range of areas, with information on item costs, materials, vendors and a whole host of other details accessible directly within a 3D model of a building. BIM principles may also offer advantages for the management of heritage sites, but using existing BIM solutions may not be straightforward. A purpose-built alternative, the Heritage Information Model (HIM), built using a current game-engine, is detailed and discussed here.

Keywords: Heritage, BIM, Architecture, Game Technology, 3D

1 Introduction

The construction industry has experienced a technological revolution with the introduction of Building Information Modelling (BIM), which has led to significant improvements in the design, development and maintenance of buildings. Meanwhile, in the heritage domain, new technologies are increasingly being used to digitally document key heritage sites in 3D. Documentation of heritage sites with 2D photos and videos has long been in use, but 3D digital models are increasingly used for accurate documentation and communication of heritage sites [1]. There has also been recent interest in the potential of adapting BIM specifically for use with Heritage sites – Heritage BIM, or HBIM [2]. This paper explores the potential for the heritage sector to successfully adopt its own form of BIM and prototypes a new platform based on commercial game technology. We note that the types and forms of data used in regular BIM differs from some of the data that could be required in a heritage context, where historical records, conservation data and ownership are generally outside of the range of information held in current BIM applications.

A brief review of BIM and HBIM is presented, along with brief insights from a series of interviews with BIM and HBIM users and developers. The development of a prototype for a Heritage Information Model (HIM), is outlined. We use a 3D data set from Provan Hall, a medieval building located in the East of Glasgow, within the prototype

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to provide context for the prototype, to demonstrate the process of developing a HIM application and model and to provide a realistic example for review.

2 Background

2.1 Building Information Modelling

The use of BIM is well established in the construction industry [3] spanning the entire life span of a building, including project planning, design, preconstruction, construction, and post-construction (operations and maintenance) phases [4]. BIM has been categorized according to the levels of information, or dimensions it provides, where 3D BIM is a model comprising a 3D visualisation with some embedded information. The 4D component of BIM is time, where BIM can represent the lifecycle of the construction of a building. Features such as cranes fencing and traffic access during construction can be simulated and planned.

The 5D component is cost, with BIM models allowing approximate construction costs to be quickly calculated through known materials pricing and estimated construction costs. 6D refers to facilities management, where model can be handed to the owner of the building and used for a variety of purposes. The model will contain all the data on the building, and operations and maintenance work required can be referenced and updated from the model [4].

Each of these dimensions of BIM models is clearly massively beneficial when constructing a new building and all should be able to be adapted to heritage models. E.g., instead of creating a development timeline the 4D could show the historical timeline, showing how an area or building has been changed over time. 5D could be applied to model the costs relating to the maintenance or conservation of a building. 6D could relate to other operational and management information, and where a site's continued operation relies on hard to repair or obtain infrastructure, this could be highly useful in practice. However, there may be distinct features of heritage buildings that mean that typical BIM packages used in construction may not be ideally suited. Indeed, where BIM is most actively used – in design and construction – is where there is typically the least need in a heritage domain.

2.2 Heritage BIM

There are a number of case studies of attempts to use BIM for Heritage. One notable example is documents a site in Batawa, Ontario, that contains a large landscape and buildings [5]. As well as typical quantitative BIM data (intelligent objects, performance data, etc.), it was noted that HBIM also looks to record other forms of data (historic photographs, oral histories, music, etc.).

A heritage reconstruction project of The Vinohrady Synagogue in Prague used BIM as a test platform [6], using ArchiCAD to model the synagogue. It was observed that areas of the building contained intricate architecture that could not be modelled in ArchiCAD, with 2D image textures placed over simpler forms to approximate the real

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architecture. The 3D modelling features of BIM applications is typically limited in comparison to that available in dedicated 3D modelling applications.
When creating the 3D model for a heritage site there may not be original plans of the building to refer to – and even if there are, these may not accurately reflect the building as-is. Alternative methods may be required to create the model – this could be acquired in many different ways, including the use of terrestrial laser scanning for a building combined with aerial LIDAR for contextual data plus photographs, onsite inspections, heritage records, etc. (c.f. [6][7]).

2.3 Object Repositories

BIM models are rarely built entirely from scratch, with most models making use of parts from a database of assets. Websites such as BIM Store (www.bimstore.co.uk) and the National BIM Library (www.nationalbimlibrary) contain a large range of models to use in projects, many of which come with a additional integrated information including manufacturer, model, manufacturer website links, and a wide range of quantitative data. Users can then easily download the models for use in their plans.

The idea of a cloud based repository to share models and materials has also been suggested for HBIM [6]. Unlike regular BIM there will be many historical a heritage projects that will contain completely unique models. One suggested solution is to use objects that have been parameterized to allow users to make small alterations to common objects. Then the models could have more value across different projects. Additionally a database of construction materials could be stored, featuring common materials from different periods and/or locations. This could reduce the workload in creating HBIM models. Where there is limited information on a heritage site, the database could still be used to provide information on the likely materials.

2.4 Visualisation and Materials

Although BIM isn't primarily about visualization, it does involve the development of 3D models – less detailed than typical for architectural visualization but allowing users to interact with the model to virtually explore a building without constraint to pre-rendered views. Although high detail photo-realistic renderings are not as important when collaborating in the design or maintenance of a modern building, this may be of more interest for heritage models, which may be site so of significant historical interest.
The problem of accurate visualization is amplified when dealing with 4D for heritage, where a model may be represented over hundreds of years. During this time the look of the building would change drastically. Although current BIM software can accommodate simulating a change in geometry it does not consider how particular materials visually change with age.

One solution for this would be to make use of tools such as *Substance Designer*, a texturing tool originally designed for games. Within *Substance Designer*, developers can apply parameters that allow the substance to change visually at run time. This can potentially be used to visually simulate surface aging effects on a wide range of mate-

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rials. Just as [6] proposed an online database of open parameter models, an online database of open parameter materials can be developed, and some already exist – though this is primarily for use in games. One problem with these online material libraries when compared to BIM stores, however, is the lack of embedded information – as these material libraries are focused on the appearance of a surface, without care for underlying information about the actual physical materials involved. *Substance Designer* does not have the capability of using the same forms of material data held in current BIM objects.

2.5 Crowdsourcing Heritage Information

Crowdsourcing allows richer data to be collected on heritage sites, in addition to the use of established data sources [8]. However, when dealing with heritage data, there are issues with conflicting information originating from different sources, and there is a risk in allowing non-expert users the ability to directly to enter data to the model without moderation. Additionally, traditional BIM software does not feature user-interfaces that support data entry by non-expert users. In developing a new prototype, a custom interface could be developed for a specific heritage project which could be used by a wider audience including historians, local community, and other parties.

3 Requirements for Heritage Information Models

To explore further specific requirements for HBIM applications, a small set of expert interviews were conducted, with a conservation architect, a BIM software developer, BIM consultant and BIM manager (the last three employees at IES Ltd., a company specializing in energy monitoring solutions for integration with BIM).

3.1 Conservationist views on HBIM

The conservation architect interviewed specializes in traditional buildings. She stressed that current HBIM models are not tackling the problems that most conservation architects have in collecting heritage information about buildings, and this type of information come from a wide range of sources – local authorities, historic interest groups and communities, and academic research papers. To meet her requirements an HBIM model should act as a “3D database” with relevant information available from within the 3D viewer itself.

She also noted that a HBIM model should allow local community engagement by empowering people to gather and publish data pertaining to a site. For this purpose, the model or database would need to be accessible to the public as well as professionals. Having all relevant information available in one place would provide obvious benefits for production of Conservation Reports and other professional documentation.

It was noted that 3D models developed from laser scans and photographs could give an accurate level of 3D representation but typically held no information on building materials or state. She saw 3D visualizations as a separate entity than HBIM, but felt

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that a platform that combined both could be extremely useful, for example by showing how the material of a building aged over time through visual. Finally, it was also noted that BIM is not currently a useful platform to store large amounts of data in a form useful for conservationists.

3.2 BIM Developers on HBIM

The problems IES have with their current BIM software is mostly user interface related. Their key concerns are: making it easier to input the information in the correct place (without have to switch between multiple windows); encouraging users to input information and making the process less laborious; and using better visualization techniques to convey information.

It was explained that IES has looked into gaming technology to improve the visualizations created for BIM. The 3D visualization they have currently uses wireframe models and colored rooms displaying energy measurements.

Viewpoint Construction Software was mentioned as an example of BIM software for viewing and collaborating on BIM models. The software has a straight forward interface and allows users to leave notes and questions in key areas and online sessions can be created where multiple users can view the model at the same time. This software is focused in retrieving information out of a model, and does not support the design or creation of a BIM model.

3.3 Requirements Summary

The requirements for heritage focused users are very distinct from those driving modern BIM software developments. Richer forms of documentation, greater abilities to add contextual data, more support for contributions from multiple users, a possible need for moderation tools, and greater focus on visual fidelity all indicate that Heritage Information Models may not be best served by using existing BIM solutions. While conventional BIM could be extremely valuable in maintaining a heritage building that is still in use, but this this would reflect only a small part of the potential of a more bespoke solution.

4 Development

It was decided to develop a prototype of a Heritage Information Modelling, HIM, system distinct from current approaches. This would focus on integrating accurate 3D data, photo-realistic visualization, 4D modelling (both in information and visuals) and demonstrate how rich third party data sources might be stored within models and linked to the 3D representation. For demonstration purposes, data was used from a previous digital documentation project at Provan Hall.

The site is in Glasgow, Scotland, located to the North-East of the city center and comprises two buildings linked by a walled courtyard. The older part dates from the late medieval period, and is owned by The National Trust for Scotland, and maintained

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by the Glasgow Building Preservation Trust and Glasgow City Council (GBPT, 2013). Provan Hall is a Category A listed building.

The buildings are currently in need of works to improve the condition of the buildings, and a major renovation project is in early stages. The North Range building - medieval in origin with later renaissance alterations - dates from the 15th or 16th century. The South Range is believed to date from the 18th century, although parts may predate this (Stuff, 1970). In 2016, the site was digitally documented by students on the MSc in International Heritage Visualisation at The Glasgow School of Art. A complete external laser scan was performed, with some internal scanning, and a 3D model developed from the scan. Additionally, a large collection of photographs was collated, allowing the resultant model to be recreated photo-realistically. For the current project, some additional work was undertaken to resolve some minor issues in the 3D model and some additional optimizations made for real time rendering.

Texturing was completed using a mixture of textures from site photographs and textures from online repositories (e.g. for roof tiles). *Substance Designer* and *Painter* were also used to develop textures that could be adjusted at real time to visually demonstrate the effect of aging.

4.1 A Game Engine for HIM

The prototype was developed using Unreal Engine 4, UE4, a high-end 3D game engine which is capable of real-time photorealistic rendering and built in support for scripting. UE4 also provides a "post-processing volume", which can be built into a scene to provide a range of visual effects which can add depth and character to a heritage building, such as color correction, light bloom or a photographic vignette effect.

Different modes of interaction are supported in the prototype – with users able to examine and navigate through scenes through point-and-click, allowing users to quickly position and control a 'flying' camera, or first-person game style navigation, allowing users to virtually 'walk' around the scene, Fig. 1.

Fig. 1. A simple HIM prototype for Provan Hall

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A key goal, informed by interviews, was to make the interface as simple as possible. The Heritage Information Model uses pop-up windows with tabs for each category of information, Fig. 2. To simplify the visual presentation, there is a limit on the number of windows open at any one time to a maximum of two. External links may additionally open in a separate web browser window. The tabs are categorized based on types of data required per the conservation architect. The first is for general and broad historical information. It also provides links to related multimedia archives associated with the currently selected building part. The second tab provides conservation information. This might contain listed building status as well as all required information related to possible conservation projects – including details of consultants, contractors and project costs.

Fig. 2. User interface with first tab active.

The third tab details building and material information, with relatively simple data format compared to traditional BIM solutions. In the case of the Provan Hall, the information includes basic materials information such as building roofing materials present in the building structure. Thumbnail views and links are also provided to the material libraries where the textures used in the model are stored – an adaptation of the BIM store concept. Finally, the fourth tab is open for users to upload additional information to the model. In the current prototype this is not implemented – a final system would also need to implement a content vetting and moderation system for user content.

Each tab contains links to websites offering additional information. This is to address the idea of a central model where all information is brought together instead of a conservation architect, historian or academic having to search through multiple sources of information to find what they are looking for. The Interface has been designed to work on tablet or PC, with a simple UI featuring large buttons and minimalist UI design – this provides the additional benefit of creating a simple system for non-expert users.

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5 Discussion

To date, only a preliminary evaluation with potential end users has been conducted. This has highlighted some need for further improvements to the UI. The feedback from the conservationist focused on a need to provide more heritage documentation within the prototype. This, however was not the intended aim of the current project, where the goal was to see if additional data could be easily added to the project after delivery – rather than to provide a 'completed' example. All participants agreed that the visualization was of a very high standard and the BIM developers and users thought this was extremely impressive demonstration of the technology.

The project demonstrates that a Heritage Information Model may be a useful tool in the heritage digital documentation process. It is suggested that bespoke tools for digital documentation and information modelling may be of more value than ones based closely on existing BIM toolsets as there are many limitations in BIM software that limit its potential for heritage information modelling. This exploration highlights a promising future for Heritage Information Modelling, informed by, but distinct from Building Information Modelling.

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A Digital Museum Infrastructure for Preserving Community Collections from Climate Change

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Abstract. Climate change poses a real and present threat to cultural heritage. Responses to climate change have focussed on strategies for prevention and physical protection. Developments in technology have made possible a new type of virtual museum that actively supports the work of museums and enables the creation of immersive digital exhibits. This paper proposes that it is important to address the role that community museums play in the digital preservation of natural and cultural heritage. It focusses on the contribution of virtual museums and proposes a distributed virtual museum architecture to support digital preservation. The architecture addresses both the need for high quality local interactions that enables preservation and the need for a global infrastructure that makes the results accessible and enables the development of links between communities.

Keywords: digital museums, climate change, immersion, heritage preservation

1 Introduction

Museums are crucial for the survival of heritage of communities, their physical culture as well as aiding in local economies. They provide a focus for regional tourism and are a vehicle for heritage dissemination. Yet museums exist in a changing world and are themselves forever changing. Climate change is creating extreme and variable weather conditions which threaten cultural heritage and the infrastructures that support them globally [1].

In the last few years 3D and 360°technologies and their associated digital literacies have spread into the mainstream. This means it is possible to create digital representations of objects and landscapes using commodity hardware already in the possession of museums and their communities. Pairing a smart phone, a cheap headset and 360°images provides an engaging and accessible immersive experience. Digital 3D models can capture the form and texture of real world objects preserving both against damage of the original. Advances in digital literacies and technologies mean virtual museum technology can be used to support and preserve the work of even small and remote museums.

This topic is critical to explore as the threat of climate change to cultural heritage is a rising danger. For example, In March 2017, museums in the Lambayeque region of Peru were damaged due to unseasonal rainfall and floods [2]. Digital preservation will enable future generations to appreciate heritage which can be suddenly lost or damaged. Work on preservation against climate change will also have applications against other dangers such as conflict, vandalism and the routine change that is part of the day to day life of museums.

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The contribution of this work is the design of a virtual museum infrastructure that will enable community museums to digitally preserve their collections in the face of climate change and other hazards.

The rest of this document outlines the context for the work, discusses the preparedness of community museums and identifies design goals for a digital museum infrastructure that will enable these threats to be countered. An architecture is presented which supports both local work and global access and a deployment strategy is outlined.

2 Museums, Preservation and Climate Change

Severe weather conditions provide a threat to landscapes, archaeology, cultural heritage and cultural heritage institutions in many parts of the globe. These threats are made worse by climate change as weather becomes more extreme and unpredictable. As recognized by the United Nations in the Paris Agreement, there is a “need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge.” [3] Valuable collections are under both direct and indirect threat of climate change; physical damage related to adverse weather versus collections housed in historic buildings that cannot adapt or be upgraded to prevent damage to objects. [4] Climate change is recognized by the United Nations as a significant threat that requires action to control and to address the effects [1,9]. The threat of climate change to cultural heritage has attracted extensive investigation including documenting the threat posed to World Heritage Sites [2,3,4] and developing policy and guides to manage risks [4,5]. The vulnerabilities of landscapes [6], archaeology, objects [7] and collections all create concern as does the effect on tourism [8].

Museums are institutional stewards of objects and histories that require protection, preservation and context. Community museums may not have the adequate storage and disaster plan in place to record and care for their physical objects and exhibits spaces if physical harm came to their museum. There has also been practical responses by museums to climate change [10,19]. This includes developing physical protection and engaging with the effects through the development of cultural narratives, construction of exhibits and engagement with communities. Museums have been active through the decades in adopting digital trends that could help ensure the permanence of their collection, but creation and access have been intended for computer specialists, not for museum staff. Recent developments in digital literacies as well as the capability of commodity computers and mobile phones promises the potential to create an innovative model of a virtual museum through web browser and apps.Virtual museums have progressed from web based collections of images, specifically-built virtual worlds, for instance Second Life, and moved towards reality based environments, such as Google Arts & Culture. However, environments like the format Google has created are based off static images; letting visitors view inside museums via panoramas using Street View technology. There has been significant interest in digital access to collections [12,13,14] and virtual museums since the emergence of the web [15,16]. There has also been ongoing research into digitization processes and some on its relation to community [20], for example the Scottish Ten project has produced digital representation of world heritage sites [17] and the

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British Museum has digitized significant portions of its collection, hosted on sites such as SketchFab [18].

Immersive and 3D technologies available today supports a more accessible form of immersive visitor online experience using mobile phones and commodity computers, which can meet institutions needs for sustainability and usability. A virtual museum can support both the full processes of content creation, management and presentation as well as enabling emergent aerial, 3D and 360°technologies to be integrated with established media to create engaging cross platform experiences.

The digital domain offers opportunities for protection from climate change however, it has real world limitations. Digitisation of a site, object or an exhibition will not offer any physical protection from damage. Consequently, digital preservation should be part of an overall strategy which both addresses climate change itself and offers what physical protection is possible. However, the 3D digitisation of an objects state if properly archived will be invaluable if the object itself is lost or damged. The digitisation of exhibitions also preserve spatial relationships and narratives. The digital domain offers the advantages that objects and exhibitions can easily be duplicated and transmitted, enabling protection through co-location and enhanced accessibility. The emerging low cost of technologies enables production of aerial, 360°and 3D technologies combined with widespread digital literacies enables community museums to create, manage and disseminate exhibits that can connect them directly with other communities around the globe.

Preservation of a communitys cultural heritage is critical due to quickly changing environments caused by climate change. By generating digital content that can be managed and accessed like a museum, the objects, stories, and digital tours can be visited and studied even if the physical counterpart is no longer accessible. Today digital literacies and technology exist which will enable a virtual museum infrastructure that offers protection against severe climate change to be designed. This process of design will need to be informed by systematic investigation. A goal will be to enable the community to continue digitizing and manage their online collections as well as utilizing the digital media to expand their online presence. However, recent advances in 3D, gaming and 360°technologies have not yet been fully integrated into the virtual museum canon. The role of virtual museums in preservation of cultural heritage [11] and the specific issues that arise when providing digital protection for community collections have not been directly addressed.

3 Community Museums, threats and challenges

Virtual Museums have the potential to ensure that the form of objects destroyed or damaged through climate change or other hazards would remain available in the digital domain. A community museum represents social history of a community often based in a locality. It connects the objects in its collections with the history and life of the community that is part of. In doing so there is the potential for active community participation in the creation of the museum, creation of its collections and curation of its exhibits.

Community museums vary significantly in size and resource. However, their location is often remote and resources modest meaning that they tend to be more

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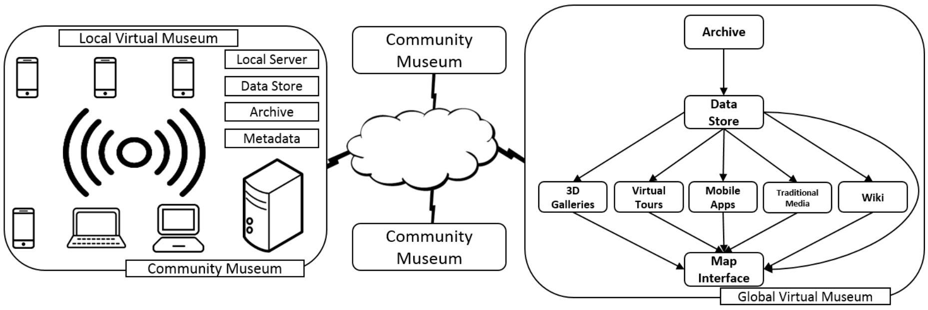

Fig. 1: DMPC4 architecture

vulnerable to the effects of climate change than large subject based museums. The connection to the Internet may be absent, unreliable or slow often ruling out direct use of Internet based digital resources in museum exhibits and exhibitions.

Their engagement with community means they have the potential to both develop and leverage the digital resources and literacies of community members in taking forward the life of the community museum. A focus on defining the cultural heritage of a particular community brings with it the possibility of sharing and connecting with other communities thereby creating direct linkages and mutual understandings that would not be possible through traditional media communications.

The vulnerabilities of community museums, the participation of community and potential for developing understanding through sharing are important factors in deciding on design priorities. Based upon the experience of working with community museums and preliminary research we suggest the need for a design which enables the following requirements to be met:

1. Digital preservation of the state of natural and cultural heritage.
2. Provision of engaging immersive exhibits, accessible locally and globally.
3. Support community participation in the creation and curation of digital heritage.
4. Be affordable through the efficient use of commodity devices.
5. Integrate with existing museum and community digital infrastructures.
6. Connect communities through enabling digital sharing of heritage.

These requirements are in part motivated by the observation that a digital museum for preservation, should integrate explicit preservation activities with a system that supports the day to day activities of a museum. This fits with the conception of an active virtual museum, which encourages participation and contribution by different stakeholders.

4 An Architecture for local needs and global reach

To achieve these goals, a global digital museum for preservation against climate change that connects community museums, provides archive facilities and enables access to immersive exhibits and exhibitions. We propose an architecture (shown in Fig. 1) which consists of a local virtual museum in each community museum and a global component they connect via the Internet.

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Each community museum will have a local system that provides responsive services and connection to the Internet. The local system will be accessible through its own WiFi access point that will enable mobile phones and computers to connect to its resources. It will have local storage that will contain an archive of media and interpretation, described through meta data. Web and app services will support both management of the archive and the presentation of exhibits. A synchronization, upload and download service will support connection to the Internet based global virtual museum. It will enable the reliable exchange of data even when the Community Museum has slow, unreliable or even non-existent Internet connections.

The global virtual museum will consist of the following components. A digital archive will hold resources from all the community museums that are associated with it. Meta data will provide context for the media, enable semantic searches and integration with aggregators such as Europeana. Support for global exhibits and connections with mapping solutions and social archive sites such as Sketchfab for 3D objects and roundme for 360°media will contribute to preservation through promotion.

5 Local Use: Immersion, Interaction and Infrastructure

A local virtual museum will be physically located within each community museum in the network. Local servers will enable resources in the data store to be accessed within the museum and its environs. It will provide the following functionality:

1. Local access to immersive and 3D exhibits on mobile phones or laptops.
2. Support for community engagement in digitization processes.
3. Support that makes it easy for communities to create interpretation and meta data.
4. A searchable archive that holds and organises digital media locally.
5. An integrated WiFi access point to enable access from existing digital infrastructure.
6. Connection with a global archive and peer community museums.

The virtual museum will combines media types through local web interfaces which create a rich and varied experience to users. Users can listen to oral histories (such as folk tales and ancient stories) or be guided around a site using audio narratives, users can undertake virtual tours of remote sites or compare the present and past states of a local site using spherical photos and videos, curators and conservators can combine digital representations of artefacts with interpretation, enabling users to explore and inspect these 3D artefacts remotely using their mobile devices, text snippets can be collectively added by community members to describe entities using an integrated wiki, and the resulting wiki articles are available to consumers to add information and context to their experiences while interacting with said entities.

What would be involved in the digitisation and how would the heritage be digitised? We propose digitising physical museum artefacts using technology already in peoples pockets and inexpensive technologies such as smartphones and digital cameras. Using cameras and free software, 3D replicas of objects can

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be created using photogrammetry, and these 3D artefacts can be disseminated over the Internet, making them accessible on websites and on mobile apps.

Smartphones can be used to capture spherical photos which can be used to make virtual tours. These virtual tours can facilitate remote exploration of sites, and coupled with cheap virtual reality headsets (such as the Google Cardboard), immersive experiences can be provided to users. Audio recordings can be used for preserving oral histories such as stories, folklores and tales, while video recordings can be used for guided tours or as part of remote virtual tours. This digital content will be described and curated using a crowdsourcing approach to metadata creation, such that community members and heritage practitioners alike can contribute to the description of digital entities. A web-based archive form will make it easy to upload meta data which, together represent and describe entities that are presented to users. Data supplied using the archive form are stored locally in a back-end Digital Asset Management System, and the data are categorised by entity type.

The local system provides a data store to the community museum digital media archive and a selection of resources from other community museums. Holding resources locally will enable provision of a high-quality web service with bespoke web and mobile applications to address digitization, description, archives and exhibitions. The 3D galleries are made up of 3D artefacts, and virtual tours are made up of photospheres, and in addition to these, other entity types include audio, flat (2D and 3D video), flat (2D and 3D) images, and museums which represent the top level entity. Web and app services will enable museums and their communities to use the phones and computers they already have and are familiar with to communicate with digital museum. An interface also connects the museum to the Internet and enables museums to upload and download resources to a global data store. Synchronization between local and global archives will enable global reach to be achieved, but not require high speed wide area connectivity.

6 Global Access, Archives, Maps and Galleries

A map interface will indicate the location of museums participating in the network. Each museum will be represented to an icon that links to digital resources connected with the museum. These resources will include: digital galleries of 3D objects held on social archive sites, virtual tours using 360°technology with embeded interpretation, mobile apps museum web pages, museum wikis and social media. A presentation front end enables the public to consume cultural heritage content that exists in the backend data store. This is improved upon by pairing the presentation front end with a management front end that heritage experts and community members alike can use to easily populate the back end with content. This is manifested in form of a web-based archive form which can be filled to supply information about a new entity, or with which content can be retrieved and edited to modify information about a new entity. The information supplied using the archive form is mapped to the Europeana Data Model (EDM, which builds on the Dublin Core schema) to leverage the literacy and familiarity of heritage practitioners with these schemas, and to improve interoperability with other cataloguing and asset management systems, towards achieving the goal of ease of management. The user experience while using the is enriched by immersive technologies including in-built support for virtual reality headsets while

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undertaking virtual tours or exploring 3D artefacts. The engaging experience is not lost in the absence of virtual reality headsets, as users can still consume the content on mobile (smartphones and tablets) and web platforms.

7 Policy and Deployment

The damaging effects of climate change to cultural heritage have been thoroughly documented and explored by UNESCO and museums across the globe. It is pressing that the causes of climate change are addressed, some combination of International agreements and social movements seems to provide some hope in that direction. In the meantime there is much that can be done to address the effects of climate change on heritage, one aspect of this is strategies for digital preservation.

This paper has focussed on community museums as they contain heritage that is valuable to the communities they represent, through their communities have untapped resources that could be mobilised for preservation and are particularly vulnerable to the effects of climate change. We propose a policy which considers the severity of the threat of climate change and the vulnerability of community museums to select museums for a program of developing digital museums for preservation in localities and connecting these to a global virtual museum. Starting with a few case studies this program will expand to a global network involving hundreds of museums. In each case training and workshops will be provided to empower communities to develop their museums.

8 Conclusion

This paper has outlined the case for designing developing and deploying a digital museum that enables community museums to digitise and preserve their cultural heritage in the face of climate change and other threats. It is motivated by the observation that developments in digital literacies, mobile technologies and media mean it is possible for community museums to create archive, present and share engaging exhibits that digitally preserve the current state of their collections.

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Workshops

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Imagine 2017 Workshop

This workshop explores how current research might be imaginatively extrapolated to explore the possible ways immersive-reality technology might change future education. In this we take a very broad vision for the delivery of education stretching from formal education at (say) university through industrial training to informal settings where we are all involved in a continuous process of learning. To this end the workshop will accept papers providing visions of the future (5-10 years out) of immersive learning environments. Papers do not need to adhere to any particular methodology but those that adhere to the Science-Fiction prototyping methodology will be especially welcomed (for more information visit **www.creative- science.org**).

The workshop will take a conventional paper presentation format consist of several 20-30 minute presentation slots. A Program committee consisting of international experts will be assembled to review papers submitted to this workshop. Each paper will receive 2 reviews.

Organisers (Alphabetical order)

- Dennis Beck – University of Arkansas, USA
- Vic Callaghan – University of Essex, UK
- Leonel Caseiro Morgado – Universidade Aberta & INESC TEC, Portugal
- Michael Gardner – University of Essex, UK
- Christian Gütl – Graz University of Technology, Austria
- Jen O'Connor – NUI Galway, Ireland
- Anasol Pena-Rios – University of Essex, UK
- Jonathon Richter – Salish Kootenai College, USA
- Oluwatimilehin Salako – University of Essex, UK
- Minjuan Wang – San Diego State University, USA & Shanghai International Studies University, China
- Jen Wu – LivingPattern Technology Inc, Taiwan
- Shumei Zhang – Shijiazhuang University, China
- Ping Zheng – Canterbury Christ Church University, UK

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Gamification and Mixed Reality Workshop

Mixed reality, the combination of physical reality with virtual reality elements, and gamification, the application of gaming principles into non-gaming contexts, are becoming more and more popular practices in education and learning context. Previous studies have shown that students can control their learning processes in mixed reality systems more actively and that gamification elements in lectures can lead to a long-term increase in the learners' motivation. But how exactly can lecturers take advantage of these benefits? How can the dependencies on a tool level between the domain (e.g. engineering) and the type of course be exemplified? And how can Mixed Reality and Gamification elements technically and didactically be implemented into education and learning environments?

These are the questions the workshop addresses.

The workshop format is designed for half a day and is based on a high level of interaction between the participants. The interaction will be fostered e.g. by discussion rounds, a requirement analysis and various team work sessions focusing on the exchange of experiences between the participants.

- Participants do not have to prepare or hand in anything in advance.
- Workshop registration is limited to twenty-five participants.
- It is open for anyone interested in using Gamification and/or Mixed Reality in their tutorials or lectures.
- A particular experience in the field of Gamification and/or Mixed Reality is preferred.

Organizers

- Freya Willicks – RWTH Aachen University, Germany
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Augmented Reality Trends in Education Workshop

The purpose of this workshop is to bring together scientists, educators, augmented reality designers, and curriculum developers to discuss and explore whether and how virtual reality may enhance learning. Scientists and augmented reality designers will present their latest results in developing augmented reality learning environments. Educators and curriculum developers will present their experience and best-case scenarios for applying those elements to their daily life teaching.

The first half of the workshop will be devoted to 7-14-28 presentations of participants' contributions. The remainder will be devoted to reflecting and mapping existing on-going work in two or three goups of participats. Key points from each group will be presented to the whole group for a final collective discussion.

Potential workshop participants are invited to submit a 2–3 page position paper following the Springer's style guidelines (http://www.springer.com/computer/lncs?SGWID=0-164-6-793341-0), describing your experience using augmented reality in learning environments and highlighting the benefits and disadvantages found when using this technology in classroom. Please send your contibution by email to mbibanez@it.uc3m.es by February 15th, 2017 to receive notification of acceptance by March 1st, 2017.

Submissions will be evaluated in terms of suitability, contribution, and interest by two PC members.

Organisers

Prof. Ángela Di Serio (Universidad Simón Bolívar, Venezuela)
Prof. Dr. María Lucía Barrón (Instituto Tecnológico de Culiacán, México)
Dr. Anasol Peña Ríos (University of Essex, UK)
Prof. Dr. Ramón Zatarain Cabada (Instituto Tecnológico de Culiacán, México)
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Posters

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Proposed Model security best practices using Immersive Virtual Reality in Social Engineering.

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Abstract. In this study is presented a virtual environment similar to the Smart cities, with the purpose of allow the user to interact with the different threats that would be exposed by the use of IT in the daily life, looking with this grant to the user a learning method in a real environment of the activities that are confronted with the practices within a smartcity, in order to raise awareness in the user variants of attacks that are submitted, using inmmersive learning as a training method. Cases of threats and vulnerabilities will be recreated with social engineering practices such as phishing, spoofing, wireless attacks and sniffers mainly. This look for to get awareness of best security practices, likewise, raise awareness that we are exposed alarming when it comes to use of technological resources as a means of support for our daily activities.

Keywords: Virtual Reality, Immersive Learning, Social Engineering, Smart Cities, Cybersecurity

1 Introduction

The use of Immersive learning as a learning method [6] will be use in this study to act as a way of training in good safety practices, regarding the use of tools presented by Smart Cities to facilitate the lives of citizens of these. With the improvements brought by these cities and the benefits also presented the risks exposed, since they represent the opportunity for hackers to obtain information due to the bad security practices that users of these services do. The present study presents several scenes that using Immersive Learning and Virtual reality will be present for try to teach users a model of good security practices, to minimize the amount of risks to which they are exposed.

These scenes are performed simulating some situations involving good security practices, such scene were done with 3dmax for the 3d models, Unity3d as game engine, and oculus is used for exposure in virtual reality.

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2 Background

The term Smart Cities is not new, it is a term that could be related to the intelligent growth used by Bollier in 1998 [1], movement of the end of the 90 that used some terms for the planning of the cities. The term evolved and was adopted by many companies in the technology area from 2005 and today becomes a daily term, using the Internet of things as a means for the development of these cities. This has brought impressive benefits to cities ranging from reduced resource use, reduced CO_2 emissions to the environment, such as New York in 2007, to the exploitation of multiple transportation systems and the implementation of these practices in the Healthcare sector.

2.1 Social Engineering

Social engineering causes millions of dollars every year to be lost through this method that cannot be detected or stopped and is based on the ability to exploit a basic human characteristic: the tendency to trust. [2] Using high-quality social engineering, combined with old exploit codes and some malicious PowerShell-based programs, the Dropping Elephant group managed to steal critical data from high-profile diplomatic and economic organizations related to China's foreign relations.

3 Proposed model

The proposed method to train people in the use of the most common stage where they may have a security problem, were made in Unity3d and will be exposed in oculus. The scenes created for these tests will be the following: Preventing Impersonating Attacks, Use of automatic cash dispensers, Unsecured Wireless connections, Forms to provide information on websites, Cellular network in secure networks.

4 Results

The result of this study will be evaluated through a security system using neural networks and evolutionary algorithms, which will allow to verify the number of incidents to which the users were vulnerable in this simulation, and with this will allow us to strengthen said security system. In order to provide users with a framework to obtain useful information on the cases to which more users were vulnerable.

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Transmedia Story-weaving: Designing immersive transmedia experiences for higher education

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Abstract. This poster outlines a research study utilizing transmedia and game elements to motivate higher education students towards higher levels of engagement and deeper learning within the theme of human rights education. This work-in-progress aims to engage students with stories of displacement via a number of different media, which will be facilitated by a technique known as 'transmedia storytelling'. The poster will concentrate on the instructional design phase of the project, and will illustrate the stories, media and pedagogic processes being used in the creation of this highly immersive learning experience.

Keywords: Transmedia Storytelling · Alternate Reality Game · Higher Education · Refugee Crisis · Game-Based Learning

1 Introduction

'Transmedia Storytelling' is a term brought to popular attention by media theorist Henry Jenkins, to denote the 'process where integral elements of a fiction get dispersed systematically across multiple delivery channels for the purpose of creating a unified and coordinated entertainment experience' [1]. Our research project sets out to better understand how this type of storytelling can be used in learning settings, to inspire and motivate young adults towards higher levels of engagement and deeper learning within the context of human rights and sustainability education. Moreover, it intends to inform the instructional design-criteria of future educational transmedia activities.

In order to achieve the aforementioned goals, we are designing an immersive transmedia experience inspired by the current refugee crisis. The participants in our project will be higher education students engaged in undergraduate studies in an Irish university. The transmedia intervention will be incorporated in the university curriculum and will form part of the formal assessment of a human rights/ sustainability course.

As the project is currently in the design phase, our poster and abstract will illustrate the design model of the intervention, highlighting the different story-levels, various

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media and pedagogic processes being utilized in the creation of this immersive experience for higher education students.

2 Designing to Inspire

For the purposes of this study the researchers have adopted a Design-Based Research approach [2, 3] that will inform all processes of design of the intervention, implementation and revision of design. During the intervention, the students will engage with a number of stories in the form of interactive game-like levels. Each level contributes to the main theme of the project: the sense of displacement. Within each level, participants will critically examine their own beliefs and values bases, engage in critical discourse on human rights issues and ultimately will be encouraged towards becoming change agents in society.

The poster will concentrate on illustrating the instructional design phase of the transmedia learning experience, and will illustrate the stories, media and pedagogic processes being used in the creation of this highly immersive learning experience.

It is proposed that Levels 1 and 2, i.e. 'Post-famine Irish Immigration (1880's)' and 'Displacement caused by Nuremberg racial laws (1935) respectively, will tell stories of displacement in prior times. The focus of the poster presentation is on displacement at current times, i.e. Level 3 'Refugees of Cyprus (1974)' and Level 4 'Today's global refugee crisis', which are explained in more detail below.

2.1 Level 3: Refugees of Cyprus (1974)

Participants will experience stories of Greek Cypriot and Turkish Cypriot refugees, who were internally displaced during the Turkish invasion of Cyprus in 1974. The students will engange with these stories via a public exhibition on the university campus. The exhibition will include among others: poems, newspaper clippings, sound and video clips, excerpts of interviews with the refugees who share their experience of displacement, and interactive elements facilitated by QR codes and tablet screens which will 'unlock' further online activities.

2.2 Level 4: Today's global refugee crisis (when does it stop?)

This level of the intervention will unveil in the form of an Alternate Reality Game (ARG) in the context of the Syrian refugee crisis. The ARG is considered a subset of 'Transmedia Storytelling', and is described as an interactive narrative 'that plays out in real time, using real communications media to make it seem as though the story were really happening' [4]. ARGs engage players in a series of challenges that are deployed both online and in the real world [5]. During our ARG, the students will 'experience' the process and challenges of seeking asylum in Ireland. In this process,

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students will navigate through real and fictional websites, decode encrypted messages, solve puzzles, gather clues and interact with fictional characters in order to progress through the story.

3 Expected Outcome

The primary focus of the study will be to ascertain the participants' levels of motivation and engagement, to map their learning pathways and to determine any changes in their dispositions, while participating in the transmedia intervention. Moreover, via the process of re-design and re-implementation we hope to inform the instructional design-criteria of future educational transmedia activities. Through the transmedia design, we aim to take the participants in an immersive journey of stories across time, and ultimately encourage the students to come to more critical understanding of refugee crises. The theme of displacement has a strong presence throughout history and seems to be a timeless phenomenon that is still current with today's global refugee crisis. Through the transmedia experience we are expecting that the students will become more aware and more understanding of the global refugee situation.

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V-Label : an experiment on how Augmented Reality impacts memorization

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Abstract. This paper presents the V-Label experiment aiming at determining whether using an augmented reality helmet favors memorization. The helmet considered here is the Hololens from Microsoft.

Keywords : Augmented reality. Memorization. Helmets

1 Introduction

During 2016 many new devices were fully developed to enable the integration of virtual worlds or to enhance the real world, VR helmets (Virtual Reality) and AR helmets (Augmented Reality). Global Forecast [1] predicts a market with 79.77 billion by 2022, where 0.7 billion dollars are dedicated to education [2]. In this context, we purchased Microsoft's Hololens offering both AR and VR, and aimed at finding out if this device could favor memorization.

2 Memorization

Among the various learning theories, behaviorism has often considered the «Learning» process as a black box impossible to explore [3]. On the other hand, there are many study with VR that measure some specifics factors during the learning process like memorization which is relatively easy to produce and measure. [4, 5, 6] We questioned whether memorization is better supported with or without the use of AR devices [7]. Azuma [8] defines augmented reality as a device which « allows the user to see the real world, with virtual objects superimposed upon or composited with the real world». Superposition can both support and harm the learning process. Experiments conducted on ordinary digital devices show how paper enables a higher memorization rate [9]. We wish to explore if a similar phenomenon occurs with disruptive devices.

3 The VR-Label project

We were inspired by Franklin Roosevelt, famous for his infallible memory for names when meeting people. He used an idiosyncratic technique by virtually writing people's names on their forehead when introduced to them. Encoding information was thus stimulated, as well as setting the conditions for the cued-recall. The VR-Label

adfa, p. 1, 2011.

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project reproduces this mechanism. The subject wears the Hololens helmet. When someone mentions his name, he repeats it and the system can then display this name on a label placed above the person whose name must be memorized.

4 Experimentation

The prototype is ready. Very soon, we shall conduct an experiment among the HES-SO's students, to compare the rates of memorization between groups with and without devices. For this test, we chose a class of students in their 1st Bachelor year in Computing, and students in their 2nd Bachelor year in Economics (48 subjects). Before starting the experiment, the students will be drawn and the random selection split into 4 groups: (Group with the Hololens 1 (GAH-1), Group with Virtual Imagination 1 (GVI-1), Group with the Hololens 2 (GAH-2), Group withVirtual Imagination 2 (GVI-2)). The Virtual Imagination groups carry out the same experiment and are required to place an imaginary label above the people introduced to them. The protocol goes as follows:

- Information on the test and the Hololens,
- Splitting into groups and realization of the experiment,
- Once the experiment is completed, each student takes an exam, to count the number of persons remembered, the number of errors. For the experiment, the photos of all the students' faces will be displayed on a hard-paper document.

The results of this experiment will be presented in a future article.

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Immersion strategies in nonfiction digital narratives: *A Short History of the Highrise*, a case study

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Abstract. This presentation introduces an ongoing PhD research about the application of immersive digital narratives to non-fiction subjects. Relying on Ryan's theoretical framing, the presentation examines the potential of immersion to engage audiences of nonfiction narratives. The proposed case study focuses on a web-documentary. The study is part in a process towards developing a taxonomy of immersive digital narratives to be applied to a broader corpus of research. Based on Ryan's poetics of immersion, the presentation examines said web-documentary's narrative structure in order to determine how the three varieties of immersion, namely spatial, temporal and emotional, can be used to promote an immersive state in a nonfiction context.

Keywords: Digital storytelling; Immersion; Interactivity; Nonfiction.

1 Introduction.

The emergence of practices such as gamification, virtual reality and playful journalism evidence that media developers are expanding their arsenal of narrative strategies.

Applied to attract audience attention in advertising and entertainment, gamification, virtual reality and playful journalism are now challenging established views on media strategies. More specifically, they have been reshaping storytelling techniques and opening new possibilities to nonfictional narratives. One example of such is the increased output in those narratives that, although not explicitly pedagogical, have undeniable educational concerns.

This reshaping trend can be observed in cyberspace, a fertile ground for practices such as transmedia, virtual reality, and playful thinking. Innovative media developers are producing narratives that take on an array of new storytelling shapes: interactive documentaries; newsgames and immersive journalism are but a sample. No matter how varied these novel shapes are, they all, nonetheless, share a common objective: engaging audiences to the point of narrative immersion.

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2 Ongoing research

My PhD research focuses on immersive digital narratives applied to non-fiction subjects. It intends to determine the digital storytelling practices that are being used to engage the public and hold its attention in non-fictional narratives. The research relies on the theoretical framework developed by Ryan's narratology studies. Empirically speaking, the investigation will analyze a corpus of research made up of two digital projects, namely (1) the *Highrise* web-documentaries; and (2) La Pena's immersive journalism pieces (the "Projects"), where each of the Projects is composed of several narratives spanning an array of different levels of immersion and interactivity.

3 *A Short History of the Highrise*: a case study

The research's analytical effort encompasses the Projects in their entirety. However, the current presentation focuses on a single web-documentary among the many that compose the *Highrise Project*, namely, the one entitled *A Short History of the Highrise* (the "Web-Documentary"). This presentation is part of my initial research towards developing a taxonomy of the different levels of narrative immersion in nonfiction contexts. It examines the structure of the Web-Documentary to answer how the three varieties of immersion identified in Marie Laure Ryan's poetics of immersion (Ryan, 2015), namely spatial, temporal and emotional, can be used to promote an immersive state in a nonfiction context.

The proposed examination begins by analyzing the very opening moments of the Web-Documentary: the director's voice inviting the audience to "sit back and relax". Then follows some brief information about navigating the system. Next, the gradual silencing of a dramatic soundtrack suggests that an outstanding experience is about to begin. The scene is evocative of the "proper ceremony" (Ryan, 2015 - 62) where Italo Calvino invites the readers of *Winter's Night a Traveller* to transit from an ordinary to a different reality. As in Calvino's book, Katerina Cizek – the director – offers *A Short History of Highrise* as a plunge into an alternative world – Ryan's "text world" – that is ultimately a source of mental pleasure. From then on, the Web-Documentary's storybook explores the 2500-year history of human life in vertical spaces.

In my presentation, I do not only indicate the elements of Ryan's poetics of immersion that are present in the Web-Documentary, but also elaborate on their potential use in attempting to engage the audience in a nonfiction context.

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The use of a Cyber Campus to Support Teaching and Collaboration: An Observation Approach

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Abstract. The research reported in this paper is work in progress describing the experiences of the authors while using a cyber campus to support online learning collaborative activities and investigate if a Transactive Memory System can be developed among group members, working together within a cyber campus in several pre-set tasks.

Keywords. Virtual Worlds: Cyber Campuses: Transactive Memory Systems

1 Introduction

The use of 3D virtual worlds in the form of cyber campuses for education has been introduced over the past few years, to support and enhance learning experiences. Cyber campuses enable students to access and participate in online learning activities, offering a range of educational possibilities that differ from the conventional online learning tools [1]. A cyber campus allows to immerse and feel present in the virtual world, facilitates communication and influences sociability between students, enabling them to be aware of others in the environment [2]. It also supports synchronous participation in realistic and/or abstract experiences, and preserves student anonymity; characteristics that support, enhance and make learning, engaging and enjoyable [1].

While cyber campuses are proved to benefit the individual learner, these can also be used as effective social collaboration spaces. Thus, an experiment was set up to investigate elements of collaboration within the VirtualSHU cyber campus, working together in several pre-set tasks. Organisational psychology has identified that the development of Transactive Memory System (TMS) has proven to be very promising for the functioning of teams and groups [3,4]. TM helps group members to be aware of one another's expertise and to divide responsibilities with reference to different knowledge areas. To the best of our knowledge, TMS has not been investigated in a cyber campus environment with the exception discussed in [5]. This paper is part of an extensive study of TMS in a cyber campus for task driven teams, and focuses only on discussing the students' experiences and observations of the researchers during the experiment. Hence, it is not conclusive as of the development of TMS among group members, and further work is on its way to investigate this.

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2 Observations and Discussion

To conduct this investigation, the VirtualSHU cyber campus was designed to support the delivery of the Introduction to ICT module. The study participants were the 1st year Business and Enterprise students at Sheffield Hallam University. A series of learning activities during weekly 1-hour sessions for 10 teaching weeks were performed. There were 4 classrooms with around 20 students each and they were divided in small in-class groups. Two sessions were running concurrently and students were meeting in the VirtualSHU. In order to investigate the development of TMS among teams, we are in the process of collecting data using the survey proposed by [3]. Meanwhile, observations and casual conversation methods have been employed to understand students' behaviour, collaboration efficiency and tendency to use the environment. The results are discussed below.

While conducting the activities within the VirtualSHU, it was observed that students were engaging in the environment and were actively participating in activities and tasks. Students were communicating from the real and the virtual world, and were keen on exploring the environment and communicate with their remote peers. Students found the environment as an interesting addition to the existing curriculum, allowing them to experience learning materials in different multimedia forms. Students acknowledged that they could interact with materials, their peers and the environment in dynamic ways. They also suggested that the environment helped them to feel more comfortable and develop trust between them. It was a common perception that while students were initially strangers to each other, the environment reduced the formality of the lesson, enabled socialisation and helped groups to develop into well performing teams. Further work is on its way to collect data and investigate the extent to which TMS has been developed among teams.

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Special Tracks Preface

Constant new innovations in the field of immersive technologies and tools attract more and more educators, innovators, researchers, designers, and developers to create content for immersive learning environments. Digital immersive education as such interdisciplinary and broad field makes research and development in this field much interesting but also complex. With the iLRN's special tracks we try to shed light on these different fields of interest and expertise and give experts a forum to discuss and present innovative and qualitative research in the emerging field of immersive education.

The special tracks of iLRN 2017 published in this online proceedings discuss and relate to the following topics related to immersive education:

- ***"Personalisation in Immersive and Game-Based Learning Environments***" is chaired by Alexander Nussbaumer, Rob Nadolski, and Samuel Mascarenhas. In this track the chairs and authors discuss elements of personalization strategies in immersive and game-based learning environments.

- ***"Digital Heritage and the Immersive City"*** is chaired by Alexandra Gago da Câmara, Helena Murteira, and Maria Leonor Botelho. In their track immersive representations of digital heritage studies are presented and discussed.

- ***"Immersive and Engaging Educational Experiences"*** is chaired by Johanna Pirker and Foaad Khosmood. The focus of this track is on design, development, and analysis of immersive and engaging educational experiences.

- ***"Wearable Technology Enhanced Learning"*** is chaired by Ilona Buchem, Ralf Klamma, István Koren, Fridolin Wild, and Alla Vovk. In this track chairs and authors discuss wearable technologies as an important part of immersive user experiences.

- ***"Serious Games using Immersive and Assistive Technologies"*** is chaired by Markos Mentzelopoulos, Daphne Economou, and Phil Trwoga. In this track the focus is to explore how assistive and immersive elements and technologies can be used to improve serious gaming.

We would like to thank the special track organizers, the chairs, the program committee, the reviewers, and the authors to make the special tracks to such an important and integral part of the iLRN.

June 2017
Johanna Pirker and Foaad Khosmood
Special Track Co-Chairs

Special Track: Personalisation in Immersive and Game-Based Learning Environments

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Analysing and adapting communication scenarios in virtual learning environments for one-to-one communication skills training

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Abstract. Studies show that pre-game content that is customized to fit a player could lead to better learning than a fixed sequence of worked examples and problem solving. A scenario is a description of a series of interactions between a player and a virtual character for one-to-one communication skills training, where at each step the player is faced with a choice between statements. A communication skills teacher/expert (author) develops a scenario in an authoring tool. A simulation presents such a scenario to a player. In this paper we apply the concept of code-smells [2] to a scenario. We define a scenario-smell as a symptom of a scenario that could be an indicator of an error or incorrect design. We use scenario-smells to evaluate a scenario pre-game. A scenario author can use an evaluation to assess and adapt a scenario to better train a player in a game/simulation. This paper presents work in progress.

1 Introduction

Many university and vocational programs train students in communication skills. Communication skills are best learned through practice, in role-play or with a simulated patient [1]. In a digital learning environment for training communication skills, a student often performs a conversation with a virtual character, and the learning environment assesses the performance of the student against learning goals for the conversation.

A student's communication skill-level varies. In a survey of Adaptivity Challenges in Games and Simulations [6], Lopes et al postulate that serious games and simulations have to become more challenging, unpredictable and player-centric, to be fully embraced as an effective way of knowledge transfer. They survey literature and games with respect to adaptivity and conclude that research focuses primarily on adaptive game mechanics, AI, NPCs, and narratives. They distinguish two adaptivity methods: on-line (or in-game) using a player model(s) to control the adaptation of NPC run-time behaviour and off-line (or pre-game) content that is customized to fit a player. An on-line method is predictable to a certain degree, as such a method requires a priori creation of variations. They also find that fewer research groups focus on off-line adaptive scenarios.

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Najar et al [8] present a study that compares student performance in a fixed sequence of worked examples and problem solving with an adaptive strategy that determines a task (worked example/problem solving/faded example) based on the amount of assistance needed by a student. Their results show that a student in an adaptive condition learns more than their peers presented with a fixed sequence of worked examples and problem solving.

A scenario is a description of a series of interactions between a player and a virtual character for one-to-one communication skills training, where at each step the player is faced with a choice between statements. A communication skills teacher/expert (author) develops a scenario in an authoring tool. A simulation presents such a scenario to a player. In this paper, we apply the concept of code-smells [2] to a scenario. A code smell refers to a common symptom of a particular error in a piece of code. For example, the occurrence of duplicated code in a program is a code smell, and often duplicated code can be removed. A code smell is not necessarily an error, but a symptom of a potential quality problem. Similarly, a scenario-smell is a symptom of a potential problem in a scenario.

This paper is organised as follows. Section 2 discusses two main types of virtual learning environments that offer scenario based assessment and training. Section 3 describes the Communicate! authoring tool. Section 4 discusses challenges in scoring a scenario and presents assumptions to evaluate a scenario. Section 5 presents the work in progress, future work and conclusions.

2 Virtual learning environments for communication skills training

Some learning environments, such as Enact [7] and deLearyous [11], offer game-play tailored to a specific psychological model. Enact [7] is based on five styles of handling interpersonal conflict proposed by Rahim [10]. Enact and similar serious games where the game-play is intrinsically bound to a specific psychological model are hard to evaluate or adapt to a new psychological model or protocol.

Other learning environments, such as Communicate! [4] and Visual Scene-Maker [3], provide an authoring tool for developing scripted dialogues. A domain expert such as a communication-skills teacher develops a scenario, including a dialogue and score(s) on a learning goal(s) in these authoring tools. A user/player plays a scenario in a learning environment and assesses her performance on the learning goals. This approach allows domain experts to develop various kinds of communication scenarios. These scenarios often follow a protocol, for example a doctor delivering bad news to a patient, or a pharmacist providing medicines to a first-time user.

Communicate! is used by more than twenty teachers/teaching assistants at Utrecht University [5] since three years. The authoring tool provides a clear separation between a scenario author and the game/simulation environment. A scenario author develops scenarios for practising communication skills without

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knowledge of the implementation of the simulation, and does not need programming skills. To find out how scenario authors experience the authoring environment, we interviewed six scenario authors [9]. In the interviews, the authors expressed a clear need for scenario evaluation.

3 Authoring a scenario in Communicate!

A scenario in Communicate! [5] is a sequence of interleaved subjects (see Fig. 1), where a subject is a dialogue between a player and a virtual character. A scenario author models a communication protocol from top to bottom. Subjects at the same horizontal level are interleaved and a player gets statement choices from these interleaved subjects with no predetermined order in a simulation.

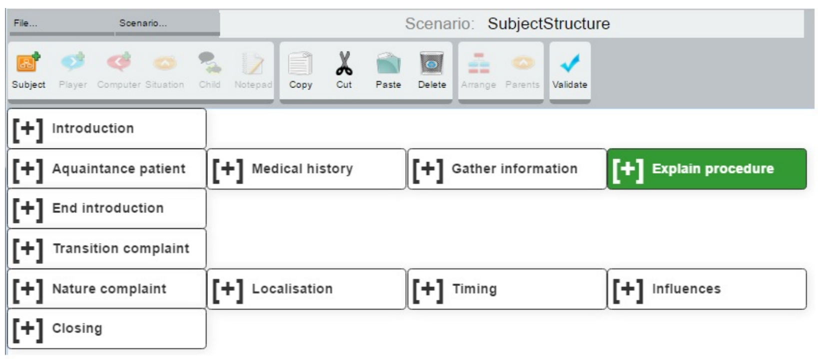

Fig. 1. Example Interleaving subjects in Communicate!

A dialogue is represented as a directed acyclic graph. Player and virtual character statements are nodes and the flow of conversation is an edge, see Fig. 2. A player statement usually has an incremental score, emotional effect on an NPC, and feedback text for a player. Multiple player nodes per computer node indicate multiple statement choices for a player.

A scenario author can further increase variability in a dialogue by marking a node with the following:

- Conditional: show only if the condition(s) is met.
- Jump: allow to jump from this node to another node in a subject at an interleave level.
- Early end of subject: allow to jump from this node to a node in one of the subjects at the same horizontal (interleave) level. If there are no other subjects at the same level, allow to jump to a node in a subject in the following vertical (interleave) level.
- End of scenario: terminate a scenario after this statement.

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During game-play, a player receives statement choices at each step in a series of interactions with a virtual character. These statement choices depend on a choice of a player and how a communications teacher scripted the scenario using the features described above. At the end of a simulation a player receives a final score on the learning goals of the scenario.

4 Evaluating a scenario

4.1 Challenges in scoring

A major challenge for a communications teacher is how to score a scenario in terms of learning goals [9].

For a single statement it is usually not hard to distinguish good and bad choices. Spreading a learning objective score across nodes in a graph is more challenging and can lead to inadvertent effects. Fig. 2 shows two examples. The left graph depicts a graph with a single scoring parameter, the right graph shows the same graph with two parameters. We show the delta scores for each of the player statement choices marked r1 to r6.

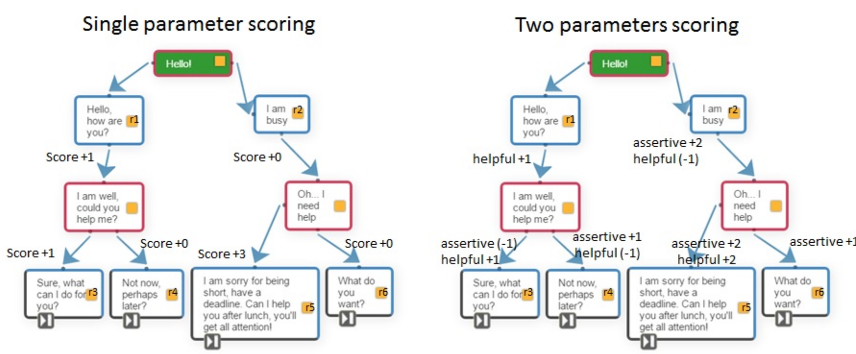

Fig. 2. Example of scoring challenges

In the left graph, a player chooses between r1 and r2 in the first step of a simulation, where r1 yields a better score. If a player chooses this option, she gets the choices r3 and r4 in the following step. A natural assumption is that choosing a statement with the highest score at each step in a dialogue results in a maximum score for a scenario. The sequence of choices r1r3 yields a total score of +2. However, the sequence r2r5 has a total score of +3, the best score for this scenario. The scenario author might have made an error, or made an explicit decision, but the situation ‘smells’.

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Scoring complexity increases with more parameters, as shown in the right graph. In this graph, the best scores are the sequences of r1r3 (yields assertive: -1, helpful: +2), and r2r5 (yields assertive: +4, helpful: +1). Note that playing the same scenario could lead to a 'helpful' or an 'assertive' player-profile. This might be expected behaviour, but scoring this scenario is more involved than with a single parameter. Scoring complexity further increases at the subject level with the use of interleaving and other features mentioned in Section 3.

4.2 Analysis of a scenario

We apply the concept of scenario smells to evaluate a scenario by making assumptions about scoring. The basis of a dialogue is a directed acyclic graph. Like the concept of a code-smell that extracts code patterns as a smell, we extract graph information and link it to scoring and other scenario characteristics to detect scenario-smells.

A common assumption is that the longest path in a dialogue graph yields a maximum score. The longest path contains most nodes and therefore has the best chance to maximize the score. Interestingly, we could also assume that the longest path does not yield the highest possible score. A player taking a longer path is perhaps inefficient. In an evaluation we report whether or not a longest path yields a maximal score.

Another common assumption is that the shortest path does not yield a maximum score. Many dialogues have at least one obstacle, such as an unwilling NPC or a bad statement choice. If a player fails to address this obstacle, the dialogue ends prematurely. This shortest path should not result in a maximum score. Sometimes, however, a more direct (shorter) approach is better, for instance in a bad news conversation. The scenario smell of the shortest path versus the maximum score should match the expectation of the scenario author.

We assume that both the minimum and maximum score of all parameters are attainable in a scenario. For example, if an author specifies that the values of a parameter are in between 1 and 10, a player might assume that 6 corresponds to a sufficient result; 8 to a good result and 10 to a perfect result. If it is impossible to achieve a score higher than an 8, then a "perfect" performance (of 8) does not correspond to the perceived result.

An interesting aspect is the relationship between parameters. For instance, if two parameters have a strong positive correlation, we could advise a scenario author to combine these parameters; since having two different parameters might be superfluous. This is conceptually similar to the duplicated code code-smell. Some parameters, for example for conflicting goals as in the right graph of Fig. 2, should have a negative correlation. The sign and degree of correlation for parameters in a scenario should match the expectations of a scenario author.

On a subject level with interleaving, Communicate! allows a player to traverse interleaved subjects in any order. We assume that a score of a path within a subject is directed related to an overall score of a scenario. If a player takes a different path in a subject that yields a higher (or lower) score, then the overall score of the player for this scenario should also be higher (or lower).

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We call a scenario that satisfies this property subject-monotone. Some subjects are required to be subject-monotone, some not. We can check whether or not subject-monotonicity holds for a scenario, and report this to the scenario author.

Some assumptions relate to graph characteristics and not to scoring parameters. Examples are: all nodes should be reachable; nodes should not connect back to a parent; every path should have an endpoint. Most of these properties are already checked in the current Communicate! editor; except the requirement that all nodes are reachable, which we will include in our evaluation-tool.

Summarising, our evaluation tool reports the following scenario smells:

- Always choosing the best option does not result in the maximum score.
- A longest path does not yield the maximum score.
- A shortest path yields the maximum score.
- The minimum and maximum score of all parameters is not attainable.
- It is possible to obtain a parameter score higher (lower) than the specified maximum (minimum) score for the parameter.
- Two parameters correlate.
- A scenario is not subject-monotone.
- Some nodes are not reachable.

5 Work in progress, future work and conclusion

5.1 Work in progress and future work

We have started with an implementation of an evaluation tool that detects the scenario-smells described in subsection 4.2 in a scenario. We report the result of a run of the evaluation tool in a report to a scenario author. A scenario author can use this report to annotate and/or modify a scenario.

A subject of future research is to perform post-game analysis on a scenario. This involves analysis of, for example a player/student(s) play-through, a statement/question(s) in a scenario that students struggle with, a scenario's contribution to learning etc.

5.2 Conclusion

Communication skills are needed in the majority of professions and are best learned through practice. These skills can be developed in virtual learning environments that simulate real-world communication scenarios, for instance a bad news conversation.

We investigate pre-game methods to evaluate a scenario from the Communicate! authoring tool and develop assumptions to analyse a scenario. We have an implementation to calculate maximum score paths in a scenario and we plan to further implement assumptions to determine scenario-smells.

We aim to provide an analysis tool for a scenario author, usually a non-programmer, to adapt a scenario to assess a student in a communication skill(s). The result of an assessment can be used to recommend an adapted scenario(s) depending on the personalised needs of a student.

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Interaction of Learning Management Systems and Gaming Platforms in the Context of Competence Based Learning

Integrating the RAGE Analytics Environment into Moodle Courses

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Abstract. E-learning standards like ***Learning Tools Interoperability (LTI)*** can support software developers and course authors at realizing innovative learning scenarios in distributed architectures. Standardized interaction processes enable learning platforms like ***Learning Management System (LMS)*** to delegate functionality to LTI-compatible external tools in a flexible way. An LTI-connection between an LMS and a gaming platform offers possibilities like embedding a game or game asset into an online course and sending player-specific data tracked during gameplay back to the LMS. This allows for a new, more objective, and data-driven evaluation of students' individual learning performances, either for traditional grading processes or for alternative methods like ***Qualifications Based Learning (QBL)*** [3-5]. This paper outlines an approach which uses standardized interaction technologies for combining game-based and competence-based learning concepts.

Keywords: Competence Based Learning, Game Based Learning, Learning Tools Interoperability, Distributed Online Courses, Moodle, Moodle Extensions, Competency Based Education

1 Introduction and Motivation

IT-infrastructures at Higher Educational Institutions (HEIs) nowadays are required to offer the best possible conditions for seamlessly integrating innovative tools and

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technologies into online learning programs. A key component for organizing and executing courses is the ***Learning Management System (LMS)*** - in many cases an open-source software based on a plugin-architecture which offers an ***Application Programming Interface (API)*** for developing extensions without modifying the core code. However, this flexible way to introduce additional functionality is not intended for the replacement of well-established e-learning tools with LMS add-ons of lower quality. In many cases, a distributed solution for transparently embedding external tools or resources into LMS-sided online courses is a better choice. The ***Learning Tools Interoperability (LTI)*** standard [1] has been designed for that purpose and provides mechanisms for authorization, authentication, tool launch, and data exchange. LTI is supported by many modern LMSs; for example, ***Moodle*** [2] offers a generic plugin for specifying LTI-connections.

LTI allows for the implementation of innovative learning scenarios within online-courses because besides, e.g., new media types, miscellaneous software systems can be easily integrated into the learning process. This includes games and gaming platforms, so LTI can be used to introduce game-based learning approaches into learning environments that originally have not been specifically designed for this kind of education. An LTI-connection between an access-protected game or gaming platform and the LMS would enable an LMS-course to embed a game or game asset as a standard course resource which can be opened from within the course. After the connection is configured, the fact that the embedded object is hosted by an external system is hidden both from producers (teachers, trainers, etc.) and from consumers (students). However, during such an applied gameplay, user-specific data about progress, status, and history have to be collected by the game or gaming platform. Especially in the context of educational games, this tracking functionality is optimized for evaluating criteria like a player's learning performance and capabilities, so on LMS-side these data can also be applied, e.g., to support some grading or certification procedures. Alternatives to traditional grading processes are competence-based approaches like the ***Qualifications Based Learning (QBL)*** concept described in [3,4,5][1]. In this case, the performance data tracked during gameplay would be used for assigning competences and updating personal competence profiles. The ***RAGE Analytics Environment (RAE)*** [6,10] is a gaming technology platform which provides appropriate tracking functionality and also supports LTI; at the moment, the developers are working on an improved solution for data exchange with LMSs. The RAE is a further development of the approaches and software systems described in [7-9].

In the remainder of this paper, we describe a way to combine game-based and competence-based learning concepts by connecting an LMS with a gaming platform and exchanging competence-relevant information. The prototypical implementation is built on top of the Moodle LMS and based on the RAE technology.

[1] Our former publications use the term Competence Based Learning (CBL).

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2 Problem Statement and Research Objectives

In a conventional learning platform like a ***Learning Management System (LMS)***, game-based learning concepts usually play a minor role because it is complex to integrate games into the learning flow. Nevertheless, to some extend it is possible to implement such approaches with maintainable effort when those software systems already support interaction standards like ***Learning Tools Interoperability (LTI)*** [1] and content standards like SCORM [11]. LTI plugins enable course authors to embed resources provided by external software systems. SCORM plugins can be used for deploying and executing uploaded games and accessing basic game-specific data (e.g. scores). A solution that depends on uploaded files and a specific runtime engine cannot be regarded as a seamless integration of external resources within a distributed architecture [3-5], so SCORM cannot be the method of choice. Embedding an externally (outside of the LMS) hosted game or game asset requires an LTI-based solution.

Nowadays, common learning platforms at least support basic LTI-functionality like authentication, tool launch inside the LMS (e.g. in an iframe), and receiving simple scores to be stored in the students' gradebooks. Regarding the integration of games and game assets, LTI's limited possibilities for data transfer between embedded tools and the LMS are a ***problem***, because a wide variety of user-specific data tracked during gameplay sessions has to be evaluated on LMS-side. Therefore, we depend on a game technology that is able to transfer the required data. This already has been subject of former research projects [6-10]; in [7] a SCORM- and an LTI-based approach are compared. As LTI's outcomes functionality was limited to a simple score at this time, the authors preferred SCORM. Since then, additional features like integration of in-house developed web services and writing access to data structures on LMS-side have been introduced to the LTI standard. This offers new possibilities regarding data exchange, so the reasons for discarding the LTI-based solution actually have to be reviewed. Nowadays, LTI-based connections offering extensive interaction mechanisms between LMS and gaming platform seem to be realistic and feasible.

As described in [6-10], a configurable tracking functionality is a key element for supporting gaming platforms at collecting user-specific information about gameplay sessions in a targeted way. In the context of game-based learning, these data are used for evaluating a user's individual learning performance; our QBL-concept (Qualifications Based Learning) adopts this approach for assigning competences and other qualifications. The consequences for and specific requirements on user tracking have to be ***researched*** and an adequate solution has to be designed and implemented. This includes an LTI-compliant transfer of user-specific, competence-based gameplay data from the gaming platform back to the LMS. Another ***research objective*** is concerned with the analysis of these data on LMS-side. Solutions have to be compatible with the competence model [5] defined within our QBL-concept.

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3 State of the Art

In the previous sections, some research projects and software systems related with our approach have already been mentioned. In the following, some of them are described in more detail.

3.1 Qualifications Based Learning

Along with the Europe-wide university-reform called ***Bologna Process (BP)*** [12], the European countries made some agreements concerning the comparability and quality of higher-education study programs, modules, and courses. As a consequence, each course has to be provided with academic credit points according to the ***European Credit Transfer System (ECTS)*** [13]. Furthermore, the conveyed qualifications have to be stated and categorized in a determined way by assigning so-called ***Competences***. A binding accreditation process which every course provided by a European university or college has to pass ensures compliance of these criteria. The fact that every course has to provide a so-called ***Learning Goal (LG)*** description containing a summary of all conveyed competences, on first sight seems to enable students to integrate a greater flexibility into their curricula. Unfortunately, that expectation has not been fulfilled; the comparability of learning content has not increased in the degree originally aimed by the BP, because competences are usually described in form of free text and every faculty in every university uses its own formulations. This leaves too much space for interpretation and misunderstandings.

As a consequence, standardized qualifications catalogues have been developed; of special interest for the IT-sector and computer science in general are the ***European e-Competence Framework (e-CF)*** [14,15] and the underlying ***European Qualifications Framework (EQF)*** [16,17]. To increase the comparability of learning content based on competences, the QBL-approach described in [3-5] includes a domain class model for representing standardized qualifications (like competences, skills, and knowledge) and frameworks like the e-CF. Furthermore, this so-called ***Qualifications Based Learning Model (QBLM)*** [5] is designed to equip competences with ***Proficiency Levels (PL)***. Competences and their PLs can be bundled to ***Competence Profiles (CP)*** which can be used as LGs in the meaning of the BP. In other words: the QBLM provides a way for modeling qualifications (e.g. competences) and assigning them to learning content. Our former publications [3-5] use the term ***Competence Based Learning (CBL)*** instead of QBL. As the approach is designed to support qualifications frameworks like the EQF and the e-CF, which divide qualifications into competences, skills and knowledge, the terms QBL and QBLM are more accurate.

Learning objects like units, activities, and knowledge resources can be represented with the ***Personal Competence Domain Model (PCDM)*** [18] which has been developed in the context of the ***TENCompetence Project (TCP)*** [19,20]. A special characteristic of the PCDM is its competence model, which later has been the extended by the QBLM. Regarding learning objects, goals, plans, and assessments, the PCDM is

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oriented towards ***IMS Learning Design (IMS LD)*** [21], a common specification developed at the ***Open University of the Netherlands (OUNL)***.

The QBL-concept assumes that competence data have to be accessed by diverse software components of an educational institution's IT-infrastructure. Within this distributed architecture, the LMS is regarded as a central element for course organization and execution, so it has to support QBL and the QBLM in any case; an extension for the Moodle LMS is presented in [5]. As Moodle already provides basic support for competences (since version v3.1), our QBL-plugin is designed as an extension for this functionality and therefore includes a mapping between the QBLM and Moodle's competence structures. The QBL-plugin for Moodle is a work in progress and not yet fully implemented.

3.2 Learning Tools Interoperability

LTI is a standard for tool interoperability that can be used for integrating externally hosted resources like forums, chat rooms, wikis, assignment tools, or games and gaming assets into learning platforms like LMS [1]. The embedding system, in our case the LMS, acts as a so-called ***Tool Consumer***. The platform which provides the external resource is called a ***Tool Provider***. The basic features of LTI are:

- ***Single Sign On (SSO)*** on the basis of a standardized authorization/authentication procedure;
- Launching external resources from within LMS-sided courses, units or activities;
- Returning a basic outcome like a score back to the LMS.

To secure access, LTI uses the standard ***OAuth*** (for more details about OAuth and security issues see [22,23]). In brief: consumer and provider exchange a so-called ***Consumer Key*** and a ***Shared Secret***. Successful validation of a request means that the sender is identified as an authorized resource from the LMS, for example a course or activity. In case of success, the next step is to verify users and their roles - do they have the permission for the requested action in the context of the requested resource? If approved, users will be logged in, a user session is created, and the provider tool is launched inside of the requesting course (i.e. in an iframe or as a separate window).

With LTI-version v2.0 [1], the concept of configurable contracts between individual consumer- and provider-side resources has been introduced. Such a contract, called a ***Tool Proxy***, among other things can be used for offering specific services on consumer-side. Regarding an integration-solution for a specific LMS, this offers interesting perspectives: providers can, e.g., be authorized to store data on LMS-side, access courses and check enrolments. However, such solutions somehow contradict the idea of standardization because they are limited to a single combination of software systems.

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3.3 Moodle as an LTI-Consumer

The plugin ***External Tool*** [24], also referred to as ***LTI-Consumer Plugin***, enables Moodle users having admin- or teacher privileges to integrate protected resources from external applications into Moodle courses via LTI. The user does not need to have any deeper knowledge about LTI, but a basic understanding is advantageous. Within a Moodle course, an LTI connection is established by creating an activity-instance of type External Tool, which contains authorization parameters and essential information like the URI of the target resource - for example an assignment or a game. From a student's perspective, the LTI-connection works like a typical LMS-activity: a click on the corresponding link opens the resource.

The basic functionality for our approach (authorization/authentication, tool launch, and return of outcomes) is already implemented by the LTI-Consumer Plugin. Furthermore, the LMS Moodle is open-source, so it offers perfect conditions for using it as a starting point for our prototypical implementations aiming at merging competence-based and game-based learning approaches by using the LTI technology. Since Moodle-version v3.2, released in December 2016, the LTI-Consumer Plugin supports LTI v2.0.

Creating an LTI connection in Moodle is quite simple, as long as the targeted software system supports LTI; at [25], a list of certified tools is provided. Gaming platforms usually will not provide LTI support, unless they are designed to be used for game-based learning approaches and data exchange with learning platforms. An innovative approach for such concepts is the ***RAGE Analytics Environment*** (see 3.5).

3.4 FUH-WebAssign as an LTI-Provider

At the University of Hagen (German: ***FernUniversität in Hagen, FUH***), several online tools have been developed during the last decades, which are individually tailored to the needs of faculty, staff, and students. Most of these initially used in-house software solutions are nowadays to some degree outdated and have already been replaced by now, but some of them are still in use today. For example, the assignment tool ***FUH-WebAssign (WA)*** [31] is widely accepted by faculty and staff because it supports some particular FUH-specific workflows. Many learning content producers worked with WA for years and spent a lot of time developing their assignment scenarios and teaching environments with it, so a mere replacement with Moodle's assignment tools has never been an option. As a consequence, WA has been kept as a legacy system and extended to support LTI [30,32]. Its new capability to act as an LTI tool provider enables course authors to embed WA-content (assignments, quizzes, tests) into Moodle courses by using the LTI-Consumer Plugin.

In Moodle, a so-called gradebook is used for recording students' individual course performance. All grades for course activities have to be registered there, including the scores achieved in external e-learning tools embedded via LTI. For transferring the required data to Moodle, WA uses the standard LTI outcomes service which is limited to a simple score and supported by Moodle's LTI-Consumer Plugin. A more exten-

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sive feedback is not necessary. As WA is not designed to support competence-based approaches directly, competences can only be attested in relation with these outcomes. For automating this process, configurable transformation rules are required on Moodle-side.

3.5 RAGE Analytics Environment

The ***RAGE Project*** [26] aims at supporting the game industry at developing serious and educational games easier, faster, and more cost-efficiently. The main objective is to develop an eco-system of self-contained gaming assets (well-documented software components) that can easily be used and included by serious games.

The ***RAGE Analytics Environment (RAE)*** [6,10], a platform which collects, analyzes and displays learning analytics data from games, uses a flexible authentication and authorization module for enabling other RAGE server-side assets to access RAE-resources by using standard interaction technologies like LTI or SAML [27]. As RAE supports such standards, it is possible to embed RAE-assets into online courses provided by learning platforms like the Moodle LMS; for a description of Moodle's capabilities regarding LTI see section 3.3. In terms of LTI, the RAE takes the role of the tool provider and manages the access to the analytics tools, which are intended to be embedded on LMS-side. Launching the actual game from within the LMS is not implemented by the RAE at the moment, but it is considered for future development.

The RAE has been developed at the *Complutense University of Madrid, Department of Software Engineering and Artificial Intelligence*, and is based on former research and software projects concerning game-based learning (including the eAdventure game authoring platform). In [7], the authors researched how to use e-learning standards to integrate games into LMS, in particular, they proposed three integration models. One of them uses LTI to facilitate the integration of a gaming platform and an LMS; another one uses SCORM. A concept for designing educational games with a view to LMS-integration and IMS LD is presented in [8]. A prototypical implementation based on the gaming platform eAdventure is described in [9].

With regard to our QBL-approach, the concept for tracking user-specific data during gameplay and exchanging them with the learning platform is of special interest. The RAE, more precisely the underlying concept for educational game design, assumes that user-tracking is already considered during game design. The tracked data then have to be returned to the LMS by using a suitable interaction mechanism. Currently, a feature for this purpose is under development: a mechanism will be provided, which allows the registration of an endpoint (webhook) that will send a notification when a new gameplay session is created and ready to process. This notification will include several ***Elasticsearch*** [28] indexes, which can be used to identify the data logged during gameplay, and the indexes belonging to evaluation data produced by the RAE analytics tools. This functionality can be used for continuous monitoring of a gameplay and establishing a data stream from RAE to the LMS, more precisely: to an LMS-extension for processing these data.

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4 Conceptual Design

Bidirectional communication between LMS and gaming platform can be implemented by using common e-learning standards like LTI [1] and SCORM [11]. On first sight, LTI seems to be the appropriate technology for integrating a game or game asset into an online course, because it assumes that the involved resources are hosted in separate systems. However, there are alternative solutions which, depending on type and extent of data exchange, might be a better choice. In [7], three models for integrating games into LMSs are described, one of them proposes the use of LTI, another one is based on SCORM. In 2013, when the paper was published, the LTI-specification has been limited to basic functionality like SSO and returning a simple score, thus the authors preferred the SCORM-based solution which allows larger scaled data exchange.

Since LTI-version v2.0 [1], which has been released in 2014, so-called ***Tool Proxies*** (TPs, see section 3.2) are part of the LTI-specification. They can be interpreted as configurable contracts between consumer and provider, which can include URIs of consumer-sided web services. In our use case scenario, this would enable the gaming platform to send user-specific performance data back to the LMS. A disadvantage of this approach is its limitation to a single combination of software systems, which is a contradiction to the idea of standardization.

As mentioned at the end of section 3.5, it is planned to extend the RAE with a mechanism that notifies the consumer about recently started gameplay sessions. The notification includes metadata which later can be used by the LMS for accessing RAE-sided information about a user's performance during gameplay. This approach might be combined with an LTI TP: a service for receiving and processing those notifications would have to be developed and declared as a so-called offered service on LMS-side. Furthermore, an LMS-sided feature for retrieving performance information from RAE based on the data within the notification has to be developed.

Different learning scenarios require different integration strategies. In many cases, it is sufficient to return a simple score back to the LMS, but complex game-based or competence-based learning concepts require detailed information about a student's actions during a gameplay. The following sections describe two typical use cases.

4.1 Basic Use Case: Simple Integration of a Game into an LMS

A browser game or a game asset which is hosted by a gaming platform is embedded into an online course provided by an LMS. The transfer of user-specific gaming data is limited to a simple outcome like a score. In this case, on LMS-side LTI-functionality like Moodle's LTI-Consumer Plugin (see section 3.3) can be used for authorization, authentication and tool launch. If not already provided by the LMS, only a web service for storing the final score in the student's gradebook has to be implemented. Competences can only be assigned in relation with this score; for automating this process, rules should have to be defined and implemented. Ideally, con-

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figurable parameters like a maximum number of attempts and conditions for overwriting an existing score should also be provided. Regarding competences and QBL, the LTI-integration of the legacy software FUH-WebAssign described in section 3.4 is a sample scenario for the basic use case.

4.2 Extensive Data Exchange between LMS and Gaming Platform

To take advantage of the data that have been tracked during students' gameplay a more adaptable integration of the game is needed which implies an extensive data exchange between the LMS and the gaming platform. Ideally, the gaming platform enables game designers and authorized users like course authors or teachers to decide themselves, what has to be logged. This can be achieved by providing appropriate APIs and configuration dialogues. The RAE , which is based on the gaming platform e-Adventure [7-9], integrates the configuration of player-tracking into the process of game design and thus provides excellent conditions for generating useful information about a player's performance.

By making player-tracking configurable, the gaming platform indirectly supports competences and QBL: it just has to be specified, in which situations competences have to be attested. Ideally, standardized qualifications from well-established competence frameworks are used because they have a unique identifier. The gaming platform does not have to support competences and competence frameworks; its responsibility ends after transferring the tracked data back to the LMS. On LMS-side, user-specific performance data have to be mapped to competence structures. This requires an LMS-extension for QBL-support; the Moodle plugin conceptualized in [3-5] could be extended for that purpose.

A sample workflow for connecting an LMS with RAEs:

1. Instructional design of the lesson plan, including activities that put into practice one or several competences. Each competence must have a unique identifier.
2. The lesson's instructional design and the specific learning goals for the game will be the input for the game design phase, during which a game design document and an instructional design document are produced. The former focusses primarily on gaming aspects and tasks like picking the right game mechanics to address the desired goals. The latter includes, among other things (context, learning scenario, environment, etc.), specifications about how to assess players' skills and attest competences inside the game. These documents are the input for the game development phase.
3. As result of a gameplay, some metrics and insights into the players' attempts for mastering the given challenges are generated with RAGE Analytics.
4. Furthermore, the LMS is notified about the students' success at achieving the assessed competences by using a suitable API. A data structure like a sequence of tuples, each tuple providing a competence-id and a rating, would be sufficient. As the LTI outcomes service is limited to a simple score, an LTI-based solution would require a Tool Proxy which specifies LMS-sided services.

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5. On LMS-side, the transferred data have to be mapped to competence structures; this requires a suitable QBL-extension.

5 Implementation Plan

The software-technical realization of the described concept is regarded as a new challenge for our QBL project [3,4,5,30] which is divided into three expansion stages.

QBL in EP (Stage 1): the foundation for a first prototypical implementation is the ***Knowledge Mangement Ecosystem Portal (KM-EP)***, a ***Typo3***-based [35] learning platform originally developed by the software company ***GLOBIT*** [37] and further improved by the ***Research Institute for Telecommunication and Cooperation (FTK)*** [36] in the Horizon 2020 Research and Innovation Action RAGE [26]. For a more detailed introduction and discussion of the KM-EP see [3,4]. Functionality for QBLM-conforming, competence-based authoring of courses, modules and study programs is implemented as a KM-EP extension called ***KM-EP CAT***. Furthermore, tools for managing and organizing competences and competence frameworks have been developed. For executing courses created with the KM-EP CAT, an KM-EP-internal Moodle installation (***KM-EP-Moodle***) is used that is optimized for the specific needs of the KM-EP. The KM-EP-Moodle itself does not support QBL; it is just used as a runtime engine for courses. The implementation and evaluation of stage 1 is widely completed and will soon be published.

QBL in Moodle (Stage 2): at FUH, the LMS Moodle is a well-established software component for course creation and execution. Since release 3.1 (Jul. 2016), Moodle offers basic support for competences and competence-based approaches by default [29]. As QBL comprises advanced data structures and functionality going beyond the standard features in Moodle [5], appropriate extensions are implemented. Furthermore, the distributed IT-infrastructure at FUH requires import- and export-processes for QBL-based courses and learning resources. Besides different types of competence-related information, LTI-based interactions with external systems are considered, even though expansion stage 2 is limited on the basic use case in section 4.1 and scenarios like the FUH-WebAssign-integration described in section 3.4. The prototypical implementation of a mapping between the QBLM and Moodle's standard competence structures is not yet completed; the development of mechanisms for specifying relations between LTI-scores and competences is in progress.

QBL in Games (stage 3): user tracking during gameplay sessions offers possibilities far beyond returning simple scores, so the second use case (section 4.2) has much more relevance for our combination of game-based and competence-based approaches. Consequently, expansion stage 3 is concerned with functionality allowing for extensive data exchange between LMS and gaming platform, which requires LTI-v2.0-features like Tool Proxies and specific web services on Moodle-side. The LTI-Consumer-Plugin described in section 3.3 enables authorized users to embed external resources into courses. Although LTI v2.0 is supported by the current Moodle version (v3.2), extensions still have to be implemented, because web services for receiving

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data from the RAE are required as well as functionality for interpreting these data and mapping them to (QBLM-compliant) competence structures. The game assets to be integrated are provided by the RAE; Single Sign On and tool launch via LTI are already supported. A capable notification mechanism for realizing extensive data exchange is in progress, for details see sections 3.5 and 4.2. As stated above, our QBLM-extension for Moodle [5] is not yet fully implemented; the postponement of the tasks described within this paper can be avoided by an interim solution that uses Moodle's basic competence functionality [29]. This temporary solution will later be adapted for QBL-conforming competences in a way that does not cause any additional effort on RAE side. Success and acceptance of the game-based approach strongly depend on the quality of the applied game, so a considerable effort has to be spent not only on software development, but also for game design and development.

Each expansion stage is regarded as a separate software project that roughly follows the OpenUP (OUP) [33], a process model that combines agile techniques and essential characteristics of the Rational Unified Process (RUP) [34] like iterative development, use cases, scenario-driven development, architecture-centric approach and risk management.

6 Evaluation Plan

The development process for each expansion stage is continuously attended by standardized quality assurance measures. Furthermore, a two-step evaluation process is scheduled, starting with an initial qualitative analysis in form of cognitive walkthroughs. Participants with complementary expertise will be consulted; in the case of expansion stage 3 (QBL in games), expert knowledge is required in the domains of Moodle, RAE, educational games, and course authoring. Technical criteria like functional capability, performance, and stability have to be evaluated both on Moodle- and on RAE side. Furthermore, attraction and applicability of our approach have to be assessed by course authors, teachers and game developers. Depending on the results of the cognitive walkthroughs, either an additional development iteration is initiated or the next evaluation step, a pilot trial with "real students". This trial will produce information about criteria like attraction for and acceptance by the students, usefulness for competence assessments, and the effort/benefit ratio.

7 Summary and Discussion

In this paper, we have described an approach for combining the concepts of game-based and competence-based learning. The key component is a bidirectional connection between LMS and gaming platform. A special property of this connection is that the interaction is implemented according to the e-learning standard LTI. This means that resources like games and game assets can be transparently embedded into the LMS, an SSO-technology is used for authentication, and the gaming platform can send data about users' gameplay back to the LMS. Based on the tracked data, competences can be assigned to students. The approach presented in this paper is regarded as an additional expansion stage of the QBL-project described in our previous publications.

The RAE already supports LTI and configurable user tracking, so it will be used as a reference gaming platform for our prototypical implementations. The LMS of choice is Moodle, which comes with LTI-Consumer functionality by standard. Based on these software systems, a solution has to be developed and implemented which improves the interaction between the involved systems in a way that allows for attesting competences to students.

In section 2, LTI's limited possibilities regarding data transfer between embedded tools and LMS have been stated as the major problem of our idea, so the main challenge and research objective of our project is to find a capable, LTI-based solution for an extensive data exchange. In this context, the requirements on user tracking during gameplay sessions have been analyzed and appropriate modifications of the RAE's tracking mechanisms have been designed. Furthermore, an LTI-compliant concept for transferring user-specific, competence-based gameplay data from RAE to Moodle has been developed. On Moodle-side, the transferred data have to be mapped to QBLM-compliant competence structures. At the moment, our solution remains on a conceptual level, a prototypical implementation is not yet available.

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Special Track: Digital Heritage and the Immersive City

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Phygital Heritage: an Approach for Heritage Communication

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Abstract. Physical heritage objects and assets are related to a vast amount of digital information of different kinds, which are challenging to be communicated to visitors in understandable and engaging ways. Yet recent technological advances promise new opportunities to more tightly merge the digital with the physical world. This paper therefore introduces the concept of "phygital heritage", the integration of digital technology 'into' physical reality, as a potential medium for more enriched and playful communication of heritage values and qualities. We propose that phygital heritage should enable the exploitation of typical advantages of both digital and physical reality, and that distinct categories of phygital can be recognized based on: 1) the level of physical affordance; and 2) in how far the technology is integrated into the physical reality. The paper also opens the discussion about the potential challenges and concerns which future explorations, scientific research and real-world applications of phygital heritage probably will encounter.

Keywords: phygital heritage, communication, physical affordance, situatedness, tangible interaction, digital heritage, physicalization, visualization.

1 Introduction

Heritage forms the evidence of the fruitfulness and diversity of our past. Accordingly, most heritage artefacts represent a vast amount of information, ranging from simple factual aspects to more complex qualitative, tacit qualities and values. Following the current movement towards the democratization of culture [1], there exists a general tendency towards making heritage information more available and accessible to the wide public, such as to make people aware of the value and richness of their and others' heritage. Heritage information tends also to be communicated to support its deeper understanding, or to engage and even immerse visitors in heritage environments [2]. Most typical forms of communication occur via conventional means, such as written labels or audio guides in museums. Yet following the rapid advancements offered by modern digital technologies, heritage information is now also increasingly represented via more dynamic and interactive formats, including websites, smart

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phone applications or virtual and augmented reality worlds. In addition, recent developments like the Internet of Things (IoT) [3] demonstrate how digital technologies are now becoming deeper integrated within the fabric of our physical reality. As such, it is claimed [3] that the Internet will no longer be only about people, media and content, but also will include real-world physical assets as networked objects able to exchange information, interact with each other as well as with people. Along with these emerging technological movements, an overarching term "phygital" has been proposed [4, 5, 6, 7, 8] that conceptualizes the blending of the physical and the digital, in so far that they do not simply complement, but rather reinforce each other. Accordingly, the term *"phygital"* was coined [4] to denote how everyday objects are connected to their environment, gathering the information and adapting their performance accordingly without human intervention.

The field of marketing has used the term *"phygital"* (e.g. [5]) as a conceptual idea that bridges e-commerce tools to physical stores, often to connect the digital presence of a brand or product to an immersive real-world experience, wherein a digital action can trigger a physical reaction, or vice versa, a physical action can result in a digital reaction. Such endeavor can be typically achieved by making the physical world a type of information system, such as by embedding machine-readable traces or sensors into physical objects so that they are able to communicate to users through digital interfaces [5]. Yet phygital characteristics can also be recognized beyond the field of marketing and retail, with application domains as diverse as education, gaming and tourism. For instance, *phygital map* (Figure 1.a) exploits the physical advantages of paper-based Atlases such as the ease of navigation and the tactile impression of browsing, and merges these with the qualities of digital media, like allowing access to a wide range of audio and video content, which even can be regularly updated [6]. Similarly, *phygital game* (Figure 1.b) adds a physical experience to a compelling digital game in order to reduce the necessary screen time in favor of more healthy forms of physical engagement [7], hereby allowing the embodiment of the user into a robot as the manifestation of the virtual into the physical. The idea behind phygital can even be deployed as a participative method, as the project *phygital public space* (Figure 1.c) [8] demonstrates how citizen engagement can be fostered via digital blogs for easily sharing and shaping their public space by stimulating interaction between the participants, gathering information and reporting the analogic data on a shareable bases. Here, the project also merges physical onsite workshops and analyses such as sound and visibility surveys to capture the flow map of pedestrian's movement in the public space, and merges all this data into a phygital experience.

Based on these theoretical and practical manifestations, we propose in this paper *"Phygital Heritage"* as a potential future research subfield, which entails how heritage information can be disclosed via simultaneous and integrated physical and digital means. By blending the digital empowerment of cultural learning, storytelling and entertainment into the heritage artefact, activity or environment, heritage forms an ideal application field to give meaning to the digital experience, and in turn, the digital medium is able to truly provide immediate access to the dynamic relevant resources.

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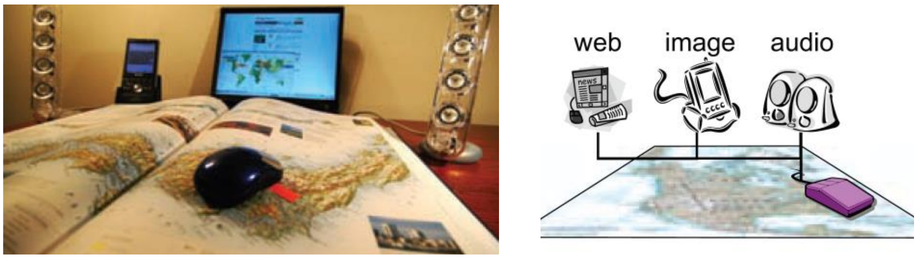
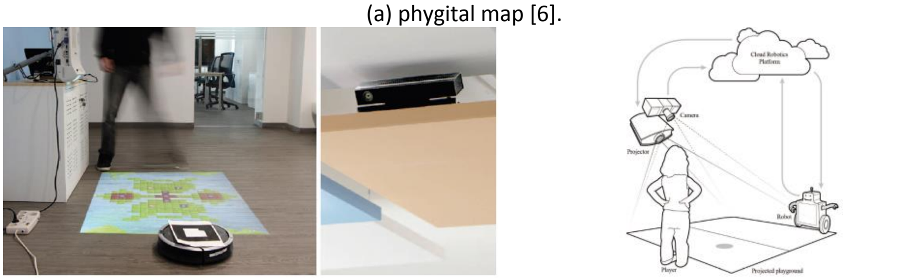
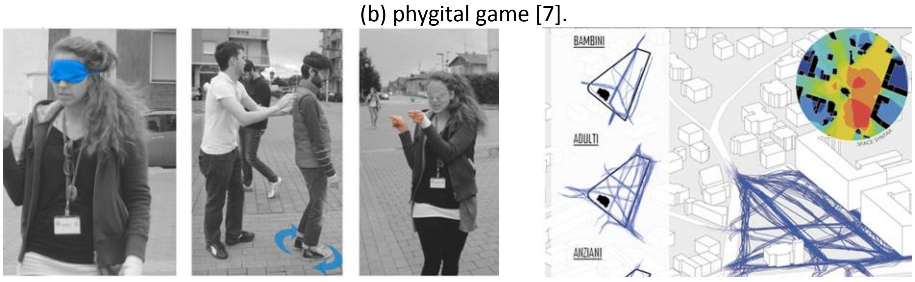


(a) phygital map [6].



(b) phygital game [7].



(c) phygital public space [8].

Fig. 1. Examples of phygital approaches: (a) phygital map: paper-based Atlas merged with digital media contents; (b) phygital game: projected playground with robot; (c) phygital public space: digital blogs and physical surveys to share and shape public spaces.

Several related domains have already demonstrated the value of the physical in human-computer interfaces. For instance, in comparison to traditional graphical user interfaces (GUIs), tangible user interfaces (TUIs) are perceived to be more compelling and intuitive to use. TUIs do not only afford objects in an abstract physical form, but they also allow the incorporation of material attributes (e.g. size, shape, texture, color, weight) in order to convey information [9]. Well-considered TUIs can also provide lay users with more intuitive affordances that steer digital actions, as physical objects tend to be more familiar, approachable, and less abstract to use than traditional digital interfaces [10]. As such, heritage communication has already benefited from recent TUI advances. For instance, tangible smart replicas have been used in museum exhibitions to provide an additional layer (narrative content) of story-telling on top of factual information presented on text labels, typically located next to the original heritage objects [11]. Furthermore, anecdotal evidence shows that the touch and manipulation affordances of TUIs in interactive exhibits tend to attract more visitors, even

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persuade them to explore further and deeper [12]. Tangible installations can also be deployed in outdoor heritage environments where lack of power supplies or digital networks can exist. For example, the '*interactive belt'* [13] supports the visit of archaeological sites by enabling visitors to select the story they want to listen to and to be part of it, triggering by specific points of interests. Another example is the utilization of a monument of urban space *'City Mouse'* as a tangible user interface [14], a landmark of a large stone sphere representing the globe, which people could push to a rolling motion in order to rotate a 3D image of the Earth that is visualized on a screen next to the landmark.

These examples, among others, demonstrate how the combination of physical and digital is still relatively unexplored, but potentially particularly valuable for the field of heritage communication, such as when the digitally augmented experience makes some sort of meaningful connection to the actual heritage context, such as the social, cultural and physical characteristics of the physical reality.

2 Phygital Heritage: Digital and Physical Characteristics

Mixed reality is defined as "…anywhere between the extrema of the virtuality continuum" [15], a continuum that extends from the completely real through to the completely virtual environment, with augmented reality and augmented virtuality taking on positions in-between. However, mixed reality relies more on displays and screens, a medium that a relatively contextless and lacks material qualities. On the other hand, we believe that phygital focuses on exploiting material-driven affordances, where the medium does not only conveys visual but also tactile qualities, in addition to physical affordance and playfulness. In the future, phygital heritage can thus be grounded on the combination of the key characteristics of both digital and physical realms for the goals of communicating and interacting with digital as well as physical present heritage information. Relevant key qualities of the digital medium include, but are not limited to:

Providing access to rich and vast forms of information. Heritage information originates from multitude of sources, and is manifested in many different forms, encompassing a vast amount of content that could potentially be disseminated. Regardless of the size, dimensionality or time-dependency of this data, digital technology allows for its immediate access through many different output media. For instance, a phygital interface is capable to convey distinct layers of information related to a heritage object depending on the actual communication medium, ranging from traditional displays to portable or wearable AR technology [16].

Personalization of information. Digital information can be offered or automatically filtered according to the profile of visitors, including their age or personal interests [17]. In addition, heritage experts can also specify the types, quantity or interpretation

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of content according to the surrounding context [18] or other kinds of dynamic constrains.

Information immersion. Digital display technology allows users to become immersed in the information, stimulating several senses (e.g. audio, tactile, touch) simultaneously in order to provide a more believable or tacit experience that better contextualizes the intrinsic values of heritage. For instance, virtual reality technology now enables users to navigate within stimulated 3D worlds that resemble the original heritage situation, in so far that it has been shown that such environments are more effective in supporting learning activities [19].

In turn, the phygital features combine the key characteristics of the physical realm that include, but are not limited to:

Physical affordance. It denotes how the physical form demonstrates the possibility of an action on an object or the environment to people. As such, tangible interfaces are capable to make use of people's experience of interacting with real world objects [20]. As such, evidence from educational psychology shows that the manipulation of physical representations of information and utilization of TUIs facilitate understanding [21]. The physical properties of heritage artefacts may thus invoke visitors' pre-existing knowledge to discover their meaning, functionality or use, and consequently lead to more intuitive or memorable forms of communication. Accordingly, phygital interfaces might thus allow users to not only touch heritage artefacts (or their replicas), providing not only the subjective experience of its shape, materiality or weight, but also for a tactile exploration of its potential use.

Physicalization. Information has already been visualized in physical manners for thousands of years, ranging from measuring instruments, passive visualizations, to more interactive forms of visualizations [22]. For abstract information, which lacks tangible counterparts (e.g. numbers, networks), its encoding into physical form (Physicalization) still improves the efficiency of information retrieval, particularly when it can be freely touched [23]. Similar physical qualities of heritage objects can be conveyed via haptic devices like "open drawer" displays, allowing visitors to reveal parts of an exhibit [18].

Situatedness. Situated communication depends on how the information relies on the "physical context" to be understood [24]. Varying degrees of situatedness exist, ranging from non-situated objects which are typically shown on museum walls or displays and thus require textual labels or legends to be understood, to fully situated objects like ruins and statues, of which the value can only be comprehended by experiencing and interpreting the surrounding context. Notably, most websites and virtual reality applications are non-situated in nature, allowing users to appreciate heritage regardless of their location yet lacking tacit and intangible qualities. Most projection map-

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pings are more situated, as the graphical depiction of the information can be directly and physically related to the artefact on which the projection occurs.

The aforementioned characteristics have been combined in our proposed model *"phygital heritage"*, shown in Figure 2. The model captures the most relevant technologies that are relevant to the integration of digital technology into physical objects in the context of cultural heritage. Such forms of integration range from separated entities that are added 'on top of' physical reality (e.g. augmented reality), to its seamless and invisible embedment (e.g. shape-changing interfaces). The horizontal axis represents the level of physical affordance, such as how the features of an interface physically support or facilitate taking an action. The vertical axis conveys the level of situatedness, or how the technology depends on the physical context to communicate information. The model considers that almost every communication technology is phygital in some way or form, but some are more phygital than others. Accordingly, the model proposes three distinct categories of phygital heritage; augmented (P1), integrated (P2), and actuated (P3).

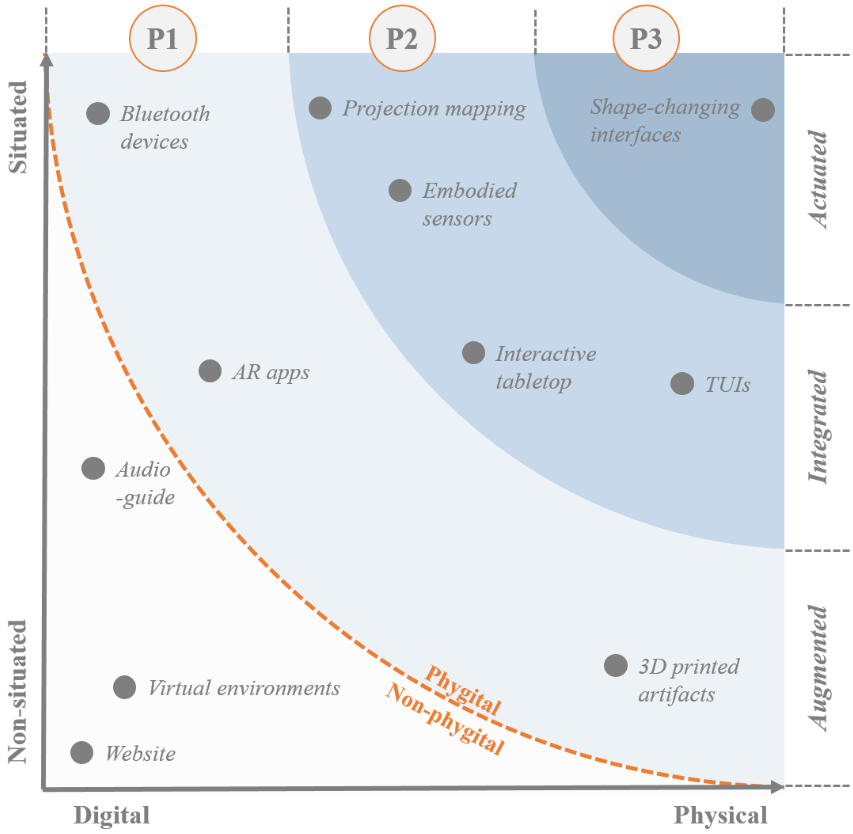

Fig. 2. Phygital heritage model, mapped along two characteristics: the physical affordance of information and the level of situatedness of how this information is communicated.

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- ***Augmented (P1)*** requires some form of continuous interaction between heritage objects or assets (physical) and electronic devices (digital). For instance, mobile augmented reality (AR) immerses visitors in a story by providing different information through texts, images and advanced 3D models via their portable devices [11]. This category also includes the use of 'beacons' (small devices that transmit Bluetooth signal to visitors' smartphones), which allow for the mapping and recording of points of interest inside heritage buildings to provide contextual information [25].
- ***Integrated (P2)*** requires users to interact with heritage objects via TUIs, which are capable of communicating information through the use of haptic rendering methods. TUIs provide users with more familiar physical objects and actions to explore, even to make sense of more abstract or less familiar digital representations. Most projection mappings also fall within this category, as its content communicates relevant contextual information, like the characteristics and cultural values of heritage (e.g. [26]).
- ***Actuated (P3)*** includes immersive and screen-less forms of interaction. Here, heritage artefacts become the output medium as the interface becomes embodied by the physical shape, behavior or materiality of the artefact itself. The emerging field of shape-changing technology forms a prime example [27], capable to physically adapt the shape of objects based on users input, as users are actually able to interpret forms, and potentially the dynamic animations that cause these shape changes. Accordingly, material characteristics of heritage objects might convey meanings by appreciating physical manifestations of these objects.

3 Challenges of Phygital Heritage

Although the phygital approach promises various opportunities for heritage communication, phygital yet comes with several concerns and challenges. Blending the digital and the physical is technologically challenging, requiring advancements from computer science, electronics and physical design. The phygital requires that sensors and different types of actuators are embedded almost invisibly, such as projection and shape-changing interfaces, and that these combinations are meaningful, respectful and intuitive to be understood and used. Publicly accessible and touchable objects require solid and robust forms of technology, which cannot be simply taken away – or vice versa, should be cheap and sustainably replicable. As such, issues of cost and ease of replacement should be well considered [11]. Therefore, the phygital poses several questions in how such interfaces can be designed, implemented or evaluated. For instance, usually visitors are not allowed to touch heritage artefacts due to obvious preservation concerns. Although some museums utilize replicas to overcome this challenge, such replicas often lack ways of communicating tangible (e.g. texture, color, weight) and intangible (e.g. worth, value, stories) forms of information, which must then be presented separately.
On the other hand, TUIs can be perceived as being intuitive and playful, causing them to be used by children, hereby opening up new opportunities to facilitate learning

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through play. Nonetheless, museum visits should not only have an educational purpose, as museums are also a place for social interaction and participation with other visitors. For that, the concept of phygital heritage might provide new solutions in how technology can truly support multi-user and collaborative forms of interaction.

4 Conclusion

This paper argues how the field of cultural heritage forms an ideal application domain to exploit the seamless blending of both digital and physical qualities to communicate heritage information in more engaging, educational and meaningful ways. The paper introduced a concise model to denote the different categories of phygital heritage according to the level of physical affordance, such as how the features of an interface physically support or facilitate taking an action, and situatedness, which is about how the technology depends on the physical context to communicate information. The paper also recognized the most important challenges for future scientific studies related to phygital heritage. This model should therefore be considered as a first step towards supporting researchers to develop more integrated and contextualized interactive communication techniques of heritage information.

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Once upon a time in Pergamon: Reality and Representation in the Hellenistic City

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A current trend in archaeological scholarship is to produce hyper-real reconstructions of ancient ruins with three dimensional modeling programs such as 3-d Studio, sketch-up and/or photoshop. Visually impressive, these images produce a false sense of completeness. While such architectural fantasies seems harmless, on certain occasions they may reflect and reproduce repressive political ideologies. An example to such a powerful imagery was 3d reconstructions of Taksim Artillery Barracks, which were produced in a book called Ghost Buildings in 2010 (Figure 1). This book included 3d renderings of ten non-existent monumental buildings from Byzantium until 1950's in Istanbul with the premise of what if they still existed. Inspired by these imagery, Turkish Government attempted to rebuild Artilley Barracks as a shopping mall in place of Gezi Park as a part of pedestrianization of Taksim project even though Gezi Park was under protection as a public green area by The Cultural and Natural Resources Protection Committee. Gezi uprising started as a public outrage at the decision in 27 May 2013 to prevent demolition of the park and reconstruction of Taksim Artillery Barracks.

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Figure 1. Taxim Artillery Barracks as Reconstructed by PATTU

In order to prevent such deception and prevention of the use of reconstructed images as a template for reality, I develop a methodology in reproducing the 3-d images of the Hellenistic city of Pergamon in Turkey. In these imagery, I combine the multiple levels of "reality" into a collage. In order not to loose touch with the present, I present 3-d architectural renderings within the current setting. In other words I collage 3-d reconstructions with the photos of ruins. As you see in figure 2, in the reconstructed image of the Sanctuary of Dionysos, the present state of ruins are given as much presence as the 3-d architectural renderings. İn my reconstructions, the idea is not to construct a representation of a past reality, but to preserve an effect of reconstruction.

Figure 2. The Sanctuary of Dionysus Reconstructed by architect Erdal Kondakci

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On some occasions ancient imagery such as a wall paintings are added to my collages so that the reconstructed image shall also give information about the past functions of monuments. For instance, in Figure 4, a wall painting from Pompei (figure 3), which represented a sacrificial ceremony performed in front of a temple, is added to the stairs of the Temple of Dionysus so that the viewers could get an idea about the ceremonial use of the staircase.

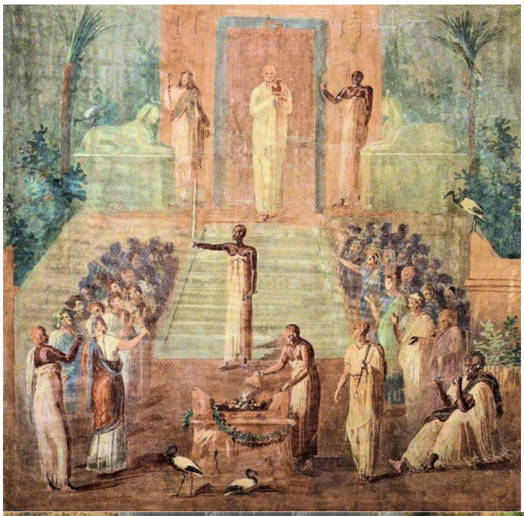

Figure 3 (left). A wall painting from Pompeii representing a sacrificial ceremony
Figure 4 (right). The stairs of the Sanctuary of Dionysos with the superimposed sacrificial scene ©Ufuk Soyoz

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Further, the inclusion of the wall painting into the reconstruction of the Hellenistic imagery was not solely made on the basis of a superficial similarity. Rather as will be shown below the superimpostion of architectural and painterly imagery was based on ancient perspectival system, *skenographia*. *Skenographia* was a painterly and architectural design method that applied Euclid's geometric definition of vision to art and architecture. *Skenographia* codified a common language among Hellenistic painters and architects and a common viewing experience of both painting and architecture along a visual or geometric movement axis. In other words skenographia connected a series of images alongside an axis into a coreography that would correspond to the movement of users within architectural space.

In order to better explain what I just said, lets look at a wall painting from Pompeii and a perspectival image of an Hellenistic sanctuary of Artemis together. The perspectival similarity of the Pompeiian painting and the Hellenistic sanctuary are that, both are designed on a space-positive mentality. As the picture frame, the temple, the icon of the sanctuary is framed with a spatial frame constituted by the stoas. The second principle is that both the Pompeian painting and the Hellenistic sanctuary tends to take shape around an axis. Just as the axis of the sanctuary conditioned the relationship between the temple and the spectator on a three-dimensional and temporal continium, the axis of the Pompeian painting was a spatial axis, that is the painter not only ordered the surface of the wall with the axis but also he determided the ideal viewpoint of the observer coordinating the eye of the spectator with the picture plane. This is an important premise, for it would mean that skenographia, the design method that applied Euclid's geometrical definition of vision to art and architecture not only codified a common language, a spatial code among the Hellenistic painters and architects, but also a common viewing experience of both painting and architecture.

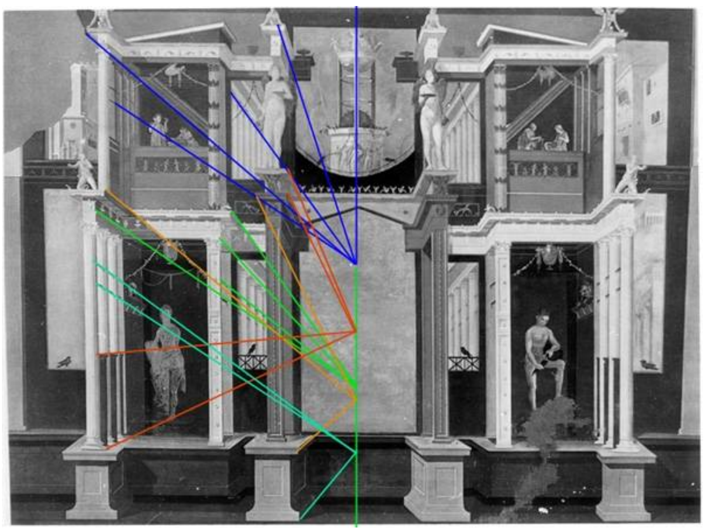

Figure 5. "Theatrical Room," House of Cryptoporticus

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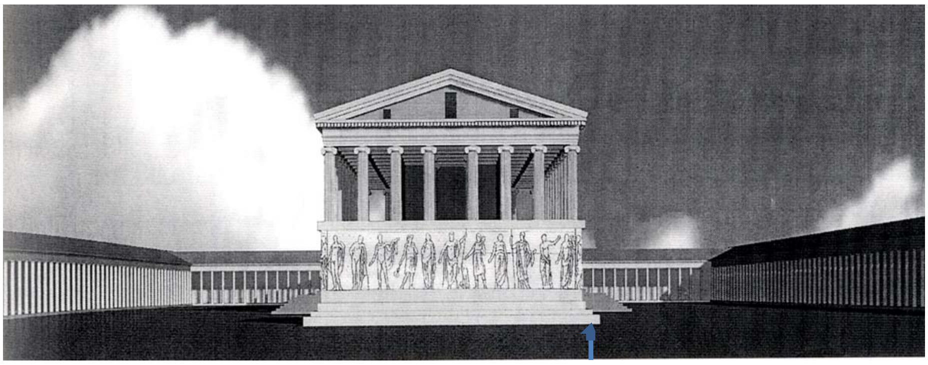

Figure 6. Temple of Artemis at Magnesia

To demonstrate what I just said, we must turn to Pompeeian paintings in their original context. In Pompeian houses the pictorial space was deliberately made continuous with the space outside it. The (cubiculum II) paintings in the House of the Griffins on the Palatine constitute the earliest example in Rome (Figures 7-8). Here, the shading system of the column bases emphasizes their projection and their perspectival decrease in size coincides with the direction of the actual movement and light source (Figure 8). The painted coulumn bases of Cubiculum II in the House of the Griffins position the viewer on an axis, defined by the entrance door and the visual axis at the back wall from the room's entryway. A person entering the room is expected to progress along this long axis, prompted by the centralized composition on the back wall and the placement of an emblema with a design in cut marble (opus sectile) marking that axis. The paintings belonging to the mature phase of the Second Style (60-40 BC) more directly addresses the spectator's movement. In the Boscoreale cubiculum for instance (Figure 9), each view opening up behind the fictive colonnade has its own visual axis. While moving along the axis, he or she is expected to assume positions defined by the visual axes of each scene. If the viewer does not position him or herself along the axis, he or she will experience perspective deformation.

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Figure 7. Cubiculum II from the house of Griffins

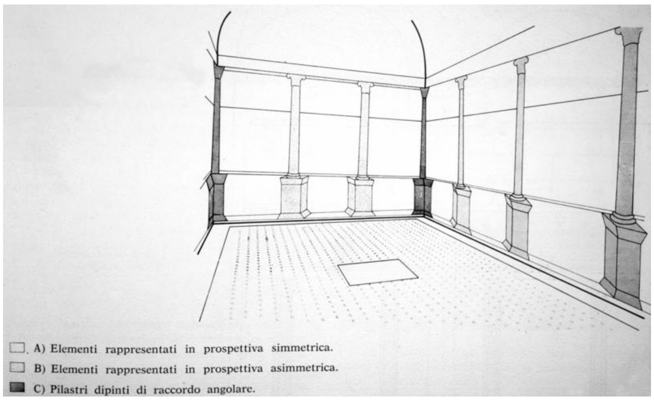

Figure 8. House of the Griffins- perspective schema

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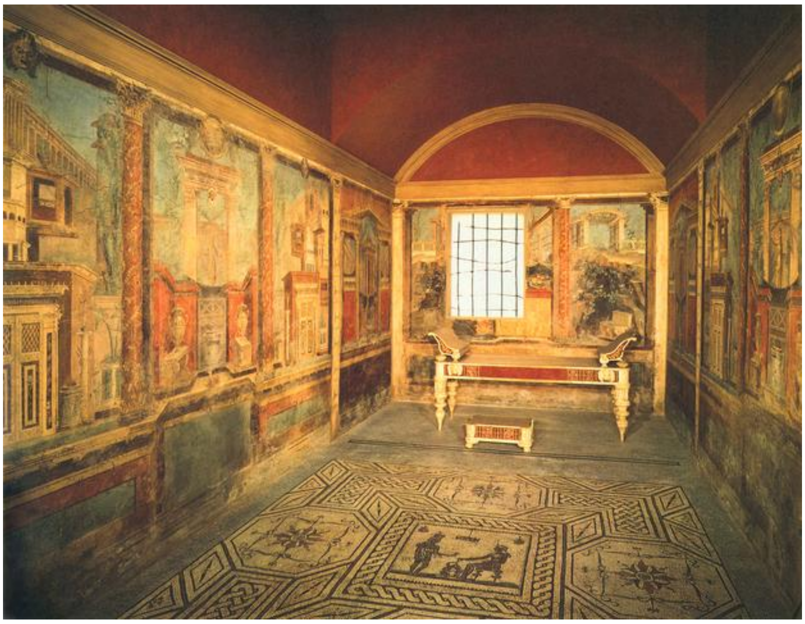

Figure 9. Boscoreale Cubiculum

As the Romano-Campanian painters, the Hellenistic urban planners were intensely engaged with the observer as they controlled the location and angle of vision, coordinating what is seen and ideally, from where it is seen by an visual axis that sometimes turned into a geometrical axis ordering the sanctuary into a symmetrical layout. Appropriate to the template provided by skenographia, reconstruction of a series of images along these axes also corresponded to the coreography of the event that is meant to take place within architectural space. Hence my 3d renderings not only give information about the past architecture but also produce a framework for the performance of events such as theatrical performances, processions and sacrifice.

For instance, the Sanctuary of Dionysus is meant to be seen and hence reconstructed as a series of snaphots along the two hundred meter long terrace (figure 10-12). This is because the sanctuary precinct had likely been used as a processional ground for a confrontation of the Hellenistic kings with their subjects. The perspectival mechanism inherent to the theater precinct created almost a cinematographic setting in which the Pergamene citizens came face to face with their king for a duration. The spatio-visual setting allowed a visual and hence power exchange between the king and his subjects. This exchange started from the entrance of the precinct (figure 10) and became more intense as the Hellenistic citizens of Pergamon walk closer to the temple front where they would see the Hellenistic king on stage (Figure 11). This visual exchange culminated in front of the altar where the citizens would perform a sacrifice in kings' honor as likely presented on the Pompeian wall painting (figure 12).

In conclusion, my reconstructions differ from the general trend in 3d architectural renderings in two basic way. First is their fictionality; their re-constructed realitys is

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made obvious with the juxtapositions of 3d rendering with the current photos of the ancient ruins. Second, my images are informed by ancient spatio-visual code *skenographia*, and hence they do not form individual images but they constitute ensembles produced from the human viewpoint. These ensembles create a scenography for the unfolding of an ancient event hence they are like a storyboard for a movie.

Figure 10. The view of the Temple of Dionysus from the entrance precinct ©U. Soyoz

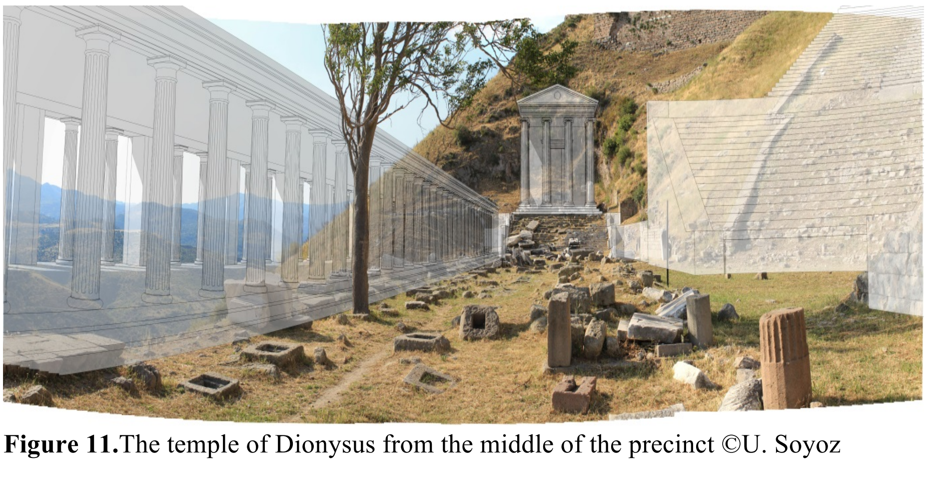

Figure 11. The temple of Dionysus from the middle of the precinct ©U. Soyoz

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Figure 12. Temple of Dionysus, close-up ©U. Soyoz

Special Track: Immersive and Engaging Educational Experiences

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Towards a Transmedia Learning Approach in ESL Context

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Abstract. Transmedia storyworlds allow students to express themselves and take part in a shared culture while developing learning paths. Whilst the use of transmedia storytelling in formal learning environments has been steadily gaining ground among educators, documented cases of its application are still sparse. This paper reports on a transmedia learning storyworld targeted to English as Second Language students by providing insight on the design of the storyworld and analysis of its core elements. The potential and challenges of applying a transmedia approach in an educational setting are explored through the description of the implementation of a prototype version of a transmedia learning storyworld and discussion of issues emerging from the application process. Based on the insights acquired during this stage, the paper concludes with a set of considerations to take into account in the development of future research in the transmedia learning field.

Keywords: English as second language · transmedia learning · transmedia storytelling

1 Introduction

In the 21st Century, students express themselves and interact within a participatory culture. In out-of-school settings, adolescents engage in new forms of cognition and communication [1] by leveraging different technologies for their own purposes, establishing social networks, engaging in sophisticated gaming practices [2], creating, publishing, and commenting on a range of multimedia texts [3]. In this context, transmedia storytelling - "a process where integral elements of a fiction get dispersed systematically across multiple delivery channels for the purpose of creating a unified and coordinated entertainment experience" [4] - "emerges as a mean of creation and expression of the Millennial generation"[5].

Transmedia learning is defined by Raybourn [6] as "a scalable system of messages representing a narrative or core experience that unfolds from the use of multiple media, emotionally engaging learners by involving them personally in the story" - intrinsically, it provides the space "to connect students with diverse content and each other" [7]. Given their affordances, transmedia ecosystems lend themselves in particular to the development of learning activities in English as Second Language (ESL) by providing a multimodal sandbox within which

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students gain a greater agency to produce language through digital formats. English language learning, in the mediated and participatory landscape of the 21st Century, can no longer be narrowed down to the exploration of the four skills: speaking, listening, reading, and writing. Competence in ESL entails not only grammatical but also communicative, symbolic [8], and relational [9] aspects which are controlled by sociolinguistic, pragmatic and cultural variables. Hence, language practice cannot be dissociated from the students' needs or language use, goals and reflections. One of the main affordances of transmedia learning environments is the potential to shift the balance of agency as students "become hunters and gatherers pulling together information from multiple sources to form a new synthesis" to become "active publishers of knowledge" [10]. They also allow to "broaden the mix of representational modes in which students express their knowledge and build collaborative knowledge cultures" [11]. Ultimately, these ecosystems aim to engage students in meaningful and authentic learning experiences by taking into consideration their contexts.

Addressing the need to map the use of transmedia learning in formal learning environments of ESL, this paper presents part of an ongoing research project that aims to deepen the understanding of the application of transmedia storyworlds in English as second language learning context. The following sections provide insight into a transmedia learning storyworld, explicitly targeted to ESL adolescent students. The next section describes the design methodology used to scaffold learning activities in the storyworld and provides an overview of the core elements that constitute the experience of the storyworld. Section three reports on the application of a prototype version of the storyworld in a formal learning environment. Finally, the paper concludes with a brief discussion of the challenges emerging from the implementation process and points to future research.

2 Connecting Cat

2.1 Conceptual Design

Connecting Cat is a transmedia learning storyworld targeted to Portuguese 10th-grade students, 16-year-old teenagers. It aims to be the setting of exploration of curricular goals of ESL, level B1 according to CEFR (Common European Framework of Reference for Languages). It is designed to engage students in the exploration of the curricular topics media culture, multiculturalism, linguistic diversity and use of technology. By taking part in the storyworld, students may enhance their language as well as their media literacy skills.

The storyworld's backdrop is an adventure story in which the protagonist seeks pieces to build a portal to connect humans to a tribe of alien warriors. In terms of narrative design, the hero's journey model was used to create an emotional connection and stimulate interest in the learning content embedded in the storyworld. Similarly to Cat's journey, the heroine of the story, students face challenges, meet mentors and are called to develop their learning path. The story is set in both a primary and a secondary world. In this manner, students

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can explore a mystical dimension, in this case, an alien warriors' world, as well as the real, through the unveiling of the protagonist's life events.

Drawing from the multiliteracy training approach proposed by Kurek & Hauck [12], the students' interactions, within the storyworld, were scaffolded around the following parameters: reception, participation, and contribution. This method "attempts to address learner literacy needs on various levels. Similarly to what is happening in a language classroom, the learner is guided from observation of the desired acts, through their interpretation to the final performance, with the teacher gradually withdrawing support" [12]. By exploring the different platforms, students are able to move from informed reception of input to responsive participation in opinion-generating activities and creative contribution of multimodal outputs [12]. Kurek & Hauck [12] argue "language learners who can comfortably alternate in their roles as semiotic responders and semiotic initiators will reflect the success of training that takes account of multimodality as a core element of digital literacy skills." To facilitate the management of learning goals, different narrative units address different curricular topics Regardless if the students explore the storyworld in a linear or non-linear manner, the narrative units are comprehensible on their own, even when explored outside the main narrative framework and encapsulate the necessary context to explore the learning content.

2.2 Core Elements of the Experience

The platforms for the storyworld were selected taking into account the learning sequence proposed by Kurek & Hauck [12]: reception, participation, and contribution. Platforms that would, on the one hand, provide learning inputs and, on the other, trigger the creation of learning outputs. The different points of access to the storyworld are set forth via a website [13], the hub of the storyworld. The navigation within the framework allows for a cumulative or complementary exploration of the elements, linear or non-linear. Below is a brief description of the main platforms that constitute the storyworld. The first three targeted to provide learning inputs the students can explore:

Who am I [14] is a webisode that establishes the essence of the story - characters, setting, and challenges. The main character is confronted with the revelation of her secret alien identity and mission. The webisode integrates a clue to two other narrative units. It can be explored to raise awareness to diverse types of linguistic discourse and discursive practices in the L2. Students can critically evaluate discourse and develop conversation skills using the webisode as a setting.

Seek and you shall find [15] is an interactive video. It makes use of the choose-your-own-adventure structure to provide a set of narratives threads that users can select and consequently create a personal experience of the story. Both the setting and characters' interactions were intentionally attuned to exploit the topics of linguistic diversity and multiculturalism. The various narrative threads provide learning inputs such as discourses representing diverse cultures, genres, intentions, communication modes and language varieties.

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Allure [16] is a motion book sequence that exploits the culture and life of the alien tribe. The user is invited to track the warrior Shakid from the moment he morphs from a cat, in the real world, into a Fluxus warrior, follow a rescue mission and his return to the real world. The events related to the mission, in particular, are set to integrate learning triggers related to the topic linguistic diversity. Allure adapts the graphic conventions of comic books and combines static art, simple animation, and sound to create a movie-like feel within the comic. Thus, it presents the potential to explore receptive communication skills and reinforce meaning through different modes of representation. By tapping into this narrative unit, students can identify biased or exploitative situations and then report and rephrase information provided visually in the sequence.

In conjunction with platforms targeted to deliver learning inputs, the storyworld is articulated around three platforms aimed to trigger the production of learning outputs:

The Fluxus Logs [17] is a blog that aims to be the alien tribe repository of knowledge "seeds" collected by humans about planet earth and its inhabitants. As co-creators of the storyworld, students can give their contribution to the assemblage. Posts on the blog include challenges that might encourage students to create, collaboratively or on their own, digital artifacts such as wikis, podcasts, videos or any other form of digital creation. This space is targeted to engage students in the topics, activate prior knowledge as well as develop media literacy skills. They are encouraged to express in a creative manner, remix and recycle modes, genres, and symbols to forge new interpretations and representations of the storyworld while channeling previously acquired knowledge and skills.

Cat's Facebook posts seek to immerse students in her quests by sharing her impressions, the challenges she is facing and asking for opinions. Students are encouraged to be active participants and expand their knowledge on the topics explored through the webisodes and motion book sequence. By interacting with the protagonist on this platform, they can address discourse issues such as argumentation and negotiation skills, pragmatic competence or netiquette in L2.

The Ed Tribe/Community is a platform specifically targeted to the use of the storyworld in formal learning environments. Edmodo integrates social networking and communication features that promote collaborative and creative practices both in the classroom and outside leading to the creation of learning paths that address the students' needs and learning contexts. It is intended to be a space for the community of students and teachers to share resources and content related to the storyworld. A set of learning resources [18] related to the story is also provided on this platform. The exploration guides to the story provide prompts for speaking activities such as group discussions or role play and a wide variety of writing prompts. The main goal is to provide a body of activities conveyed via personal accounts as much as factual texts reflecting an authentic variety of sources taken from the English speaking world that teachers can select according to the students' needs. The learning activities can be shared, remixed and enhanced by educators or students.

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3 Application of the Storyworld Prototype in Formal Learning Environment

Upon completion of the design stage and the development of the experience, several questions remained answered, namely: if the story was engaging thus fostering learning practices within a formal learning environment; whether or not students felt compelled to complete the whole experience and if the learning content encapsulated in the different fragments of the story was interesting enough and understandable to the students. Ultimately, could the storyworld provide a sufficiently satisfying learning experience to the students. To attain a preliminary assessment and collect feedback regarding as to how students would respond to the storyworld, an exploratory test was conducted.

3.1 Methodology

The pilot study followed the design-based research methodology mostly due to its central focus on tackling complex educational problems and given the complexity that entails the analysis of a learning experience and the assessment of an artifact such as a transmedia storyworld. The first iteration of the storyworld was implemented in three 90-minutes ESL classes with 24 tenth grade students at an urban secondary school in Portugal. The number of students didn't vary across the three sessions. They spent the 90 minutes sessions working on activities and assignments related to the storyworld. The researcher took part in the experience as observer and participant, and the classes were co-taught with the teacher. Throughout the three sessions, student and teacher observation and interviews were conducted, and artifacts collected. The sessions were recorded for transcription purposes and also to collect data regarding interactions between teacher/ students and between peers. Prior to the implementation stage, the teacher had access to all the content the students would engage with and was given instructions on how to interact with the various elements contained within the storyworld. Students had previously had contact with the curricular topics that are at the core of the storyworld since the sessions were set at the end of the school year. During this research cycle, the pedagogical sequence: reception - participation - contribution wasn't followed taking into account the goals of the pilot study - elicit overall feedback from users regarding the use of the storyworld for learning purposes. Nevertheless, at different points of the pilot study, students were specifically instructed to participate in the storyworld by producing digital artifacts or by being active participants in the story through a quest set via QR codes and augmented reality triggers.

In the first session, students were allowed to explored the storyworld without guidance from the teacher or researcher. To track the students' experience, a hash number was generated and saved on the client side. In this manner, it was possible to identify which access points the students had accessed to and through which sequence they had engaged with the different platforms. Using Google analytics features, it was also possible to monitor how much time students spent exploring the various platforms of the storyworld. The majority of the

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students preferred to explore the motion book sequence and the interactive video. Returning on separate occasions during the session to replay the content on these two platforms. In the last 30 minutes of the session, in groups of four, the students exchanged information with their peers about the story and tried to map the events of the main protagonist. All groups were able to track the main events of the protagonist. During the second session, students were asked to focus on the Fluxus Logs blog, select one of the available posts and submit a digital artifact related to it. The remaining 30 minutes were used to discuss what they had learned through the exploration of the blog posts and the creation of their digital artifacts. In the last session, students took part in one of the protagonist's quests. They were encouraged to help Cat to find the location of one of the portal pieces and its kidnaped guardian. The triggers for the quest were set via the mobile augmented reality application Aurasma and QR Codes. Throughout the quest, students had to solve clues and provide information to Cat. The remaining 30 minutes of the session were used to collect feedback on the overall experience of the storyworld. The students also provided feedback through a questionnaire provided at the end. The feedback activities were integrated into the sessions as opportunities for students to interact and engage in reflective practice using L2.

3.2 Research Insights

Previous to the sessions, to collect data that might help target their needs as participants of storyworld and improve it according to their preferences and insights, they answered a questionnaire concerning their social media consumption habits and their presence in the online world. More than 80% stated to prefer to be online through their mobile phones. The majority of the class (more than 70%) reported spending an average of two to five hours a day online mostly on social networks (74%) or playing games. 61% students are members of more than three social networking sites. Regarding preferences, the students prefer to use Facebook to interact with peers - more than 90%, but some also frequently interact on the Tumblr and Instagram platforms (36%). 70% play multiplayer online games and prefer action, and adventure games such as League of Legends or GTA V. The collection of this data allowed posteriorly to improve upon the first version of the storyworld by including access points in platforms that were more relevant to the students namely the Instagram platform.

Following the sessions, a feedback questionnaire was used to ascertain students' attitudes toward the storyworld. Students were asked a number of questions concerning the different platforms they had interacted with. The questions were presented as statements with Likert-type responses. Students could indicate how much they agreed or disagreed with each statement on a scale from 1 to 5. The questions referred to the following themes: quality; learning and engagement. They were also asked to rate the elements of the storyworld. Table one presents the average ratings received from the students (based on a scale of 1 to 5, with 5 being the highest).

Through the feedback questionnaire and discussion activities, participants had the opportunity to provide their insight on how the storyworld could expand.

DOI: https://doi.org/10.3217/978-3-85125-530-0-38

	Quality	Engagement	Learning
Webisode 1	3	4	3
Motion Book Sequence	4	5	4
Interactive Video	4	4	3
Blog	4	4	4
QR / AR Quest	4	4	4

Table 1: Average ratings received from students during the first iteration.

They suggested that the integration of an Instagram account could help track Cat's quests and that they could have an active role by creating their own Cat's adventures.

Although students provided positive reviews to the site regarding navigation and web design, they suggested more guidance should be added. These concerns were addressed subsequently resulting in the integration of supplementary structured menus in a new version of the site.

A significant amount of challenges emerged during the sessions. Often students expected direct guidance from the teacher or researcher to explore the storyworld, and while developing their digital artifacts, they were not aware of intellectual property rights concerning the resources they had used. During group work, some participants demonstrated a lack of collaborative culture in interactions with their peers. This was particularly visible during the quest activity and interfered with the completion of the mission. Taking into account the qualitative and quantitative data collected, future research cycles should address the fact that students in a class present different levels of media literacy proficiency and the need to raise awareness to digital copyright use. In the next stage of research, a new iteration of the prototype will be explored in an ESL formal learning environment to acquire insights on how the pedagogical sequence: reception; participation and contribution via learning input and output platforms can be applied through the use of a transmedia storyworld.

4 Closing Discussion

Connecting Cat, as part of an ongoing research project, aims to deepen the understanding of the implementation of transmedia storyworld in ESL learning context - how it can communicate the complexity and context of a story and its learning content via the use of media platforms as well as achieve students' engagement and participation. Researchers have demonstrated through empirical study that learning is inseparable from the cultural identities, practices and material settings of everyday life yet in schools educators and students seem to have little control over what happens in their classroom [19]. Transmedia storyworlds targeted to learning have the potential to create a participatory space for students. Knowledge and skills can be shared around a shared purpose and enhance creative production. In other words, transmedia storyworlds can be viewed as spaces in which students feel connected.

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Although this paper only reports on the preliminary stage in a research process to assess and improve the storyworld, the data collected during the pilot study indicate the storyworld has the potential to be explored in an ESL learning context. The implementation of future versions will hopefully yield more insights on to how to use transmedia learning storyworlds in formal learning environments.

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Travel through the oceans: augmented reality to enhance learning in early childhood education

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Abstract. Early education plays an important role in the education system and students success in a digital society. Kindergarten pedagogy innovation by integrating technology is recognized as lacking research, however an area which needs to be improved. In this context, augmented reality showed an unprecedented growth, particularly in what regards society and marketing purposes, being recognized as having great potential this decade in the educational innovation area. This ongoing research-based methodology aims to understand both students and educator's perceptions, abilities and difficulties in using augmented reality. The Case study reports to a Portuguese kindergarten with a class of five-year old students (N=24). The project was designed to enhance children's knowledge about the ocean species´ characteristics (habitat, length/ size, food). A world map was produced and augmented reality was added to improve their motivation in the learning process and to acquire research skills. Furthermore, the study provides evidence of AR capabilities to promote interactive and collaborative work.

Keywords: Kindergarten, Augmented reality, Early education, Geography, Research Project

1 Introduction

According to ODCE, PISA study students that attend preschool had higher scores than those that did not [1]. The efforts that governments are making to introduce new pedagogical experiences using ICT can be acknowledged. ICT is currently being recognized as an important engine for teaching and learning process proving to have positive effects on children's learning and development [2]. Society is being shaped by digital tools and schools should not ignore this fact [3, 4]. Students that are not able to move inside today's complex digital world can be excluded from society and schools should provide tools to develop students' skills to navigate in society's requirements.

In the meantime, pre-school practitioners and school teachers tend not to leave their comfort zones, perpetuating the traditional ways of working, particularly in preschool [5, 6]. Increased access to computers, tablets, mobile devices with both faster and greater capacities of internet connection are not increasing the use technology in the classroom, particularly in early childhood education [7]. Further when used a more meaningful and student-centered is required to jump from traditional methods and not

adfa, p. 1, 2011.

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use technology as some “benign addiction” [6]. Moreover, this “digital natives” generation [8, 9] constantly uses technology in their everyday life, particularly with the WEB 2.0 increase in tools. Hence, the focus should be oriented towards the “verbs of learning”, such as understanding, communicating, presenting, persuading rather than, to simply focus on the tools given that they are ever changing and growing rapidly [10].

As [10, 11] encouraged that “pedagogical efforts should emphasize how, not what, technology should be used in order to achieve meaningful learning outcomes”. The authors claim that for the concept of authenticity based on [12] ideas where technology should enable users to do real work and “facilitate authentic student learning” [10].

Some barriers have been identified as the main stream for not use more intensively ICT [7]. Until the turnover of the century mainly external teacher barriers was prevailing and was related with resources, training and support. In the meantime, several efforts have been done and nowadays are recognized teacher/educator internal barriers such as believes, attitudes, knowledge or skills to use technology.

Recently identified was the 21st century's knowledge and skills in educators’ preparation need in order to better prepare students for the complex world. The main learning skills pointed out were Critical Thinking and Problem Solving, Communication, Collaboration and Creativity and Innovation, in which Information, Media and ICT literacy play an important role [13]. Augmented Reality can be used as a tool to achieve those goals. Augmented Reality is recognized as

> “one of the most interesting emergent technologies for education, being a powerful and motivating tool which can involve several of the student´s senses by means of the proper and correct combination of sound, sight and touch. Application of AR technology in education is only just beginning to be explored, especially using it with preschoolers” [14].

This research is based on an ongoing project that started in September 2016, and aims to finish in July 2017. It envisages to answer the following research questions:

- How does using AR motivates children in the learning process?
- How can AR promote creativity in early childhood education?
- How impaired (autism) students perceive AR activities?
- How AR engage students with different knowledge levels?

The aims of this research is to contribute to the knowledge of AR, as an advanced ICT and its benefits on students and educators engagement and motivation. It is a pioneer study in Portugal and will contribute to international knowledge on the area also. This first paper focuses on the preliminary results analysis.

2 Augmented reality and Education

AR has emerged in 1990 [15] and research in education context is in an early stage [16]. In education, active learning strategies are being affirmed as prideful in the way that they engage students in their own learning, including for example, group work or promoting the use of ICT. Also acknowledged is that young learners want to know, to

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explore, to ask, to do and they are active and curious; learners [17]. Youngsters need to use technology to reinforce their skills; skills that are required for the 21st century's challenges and also for them to be able to use and let loose their imagination. [18] states that the “child learns through making his or her physical connections with the world…” and “the combination of intrinsic motivation and self-belief enables children to engage actively as learners … with new skills and ideas”[17].

From the beginning of this century several case studies, in several countries have been implemented in order to understand the contributions of Augmented Reality (AR) for educational purposes. Studies tend to analyze parents influence, students’ motivation and learning outcomes, knowledge and creativity, along with the degree of satisfaction (Table 1).

Table 1. AR studies in the 21st century

Year	Authors	Country
2002	Kritzenberger, H., Winkler, T., & Herczeg, M. Winkler and Herczeg	German
2003	McKenzie, J., & Darnell,	New Zealand
2007	Dünser, A., & Hornecker, E.	New Zealand
2007	Chen, Su, Lee, & Wu,	Taiwan
2008	Lee, H., Lee, J.	Korea
2010	Hsieh, M. C., Lin, H. C. K.	Taiwan
2013	Ángela Di Serio, María Blanca Ibáñez, Carlos Delgado	Spain
2013	Cascales et al.,	Spain
2013	Tomi and Rambli	Malasya
2015	Rabia M. Yilmaz	Turkey
2015	Yujia Huang, Hui Li & Ricci Fong	China
2016	Yilmaz, R. M.	Turkey

There is a difference between Virtual Reality and Augmented Reality, since the later adds artificial information into the real world while in the first, the user is completely immersed [19]. AR creates a bridge between the real and the virtual world using an application at a real time. It allows one to include live time of 3D objects, texts and sounds, on real images and video. Some authors suggest that AR should be defined broadly [20], where “AR could provide users with technology-mediated immersive experiences in which real and virtual worlds are blended” [21]. AR deals with real environments but augment them [22].

The use of AR in education is still at an early stage but results already point out important learning effects. Some of them related with, handling the information in a new and interactive way, with search skills, spatial knowledge and thinking, improving

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skills for the information-age, increasing student´s motivation, improving accurate knowledge, manipulating virtual environments or enhancing psychomotor skills[20].

Besides the recent attention of educational benefits´researchers, AR is being referred to as an emergent technology for the near future [20]. The author recognizes the connection between different innovative technologies, such as mobile devices, laptops and immersion technologies, that AR permits but highlights the need to better understand the educational value of AR.

Due to its promising input, research in different contexts such as marketing or tourism opportunities is also growing. Nevertheless there is a lack of research on educational environments and more empirical studies and evidences of the effects of AR on teaching and learning, particularly regarding preschoolers, needs to be carried out [1, 20, 23].

3 Case study and methods

This paper is based on an ongoing master research that started in September 2016. This exploratory research is based on an empirical study implemented in a Kindergarten located in an Oporto metropolitan region of Portugal. There are 24 participants, they being 5 year children, of which 13 are boys and 11are girls. Special attention will be paid to the outcome of 2 children with autism, who generally manifest less interest and participation. The institution adopts the project´s methodology. The Ocean Project was chosen for this year and the AR research was undertaken to answer these same projects. Blippar builder application was used to develop the augmented reality and ArcMap was used to create the world map, using the oceans basemap.

The convenience sampling method was used. Instruments will be from a qualitative research, questionnaire, observation form and photographs. The project was implemented in successive and integrated phases according to the student’s preferences:

Phase 1

- Students were challenged to choose one ocean species that they wanted to know more about;
- A matrix of chosen species was produced and a voting process was implemented to obtain the final 12 species (Figure 1);
- Phase 2
- Students were challenged to do research at home with parents about one specie;
- Students were challenged to draw the specie (Figure 1);
- Each week a new species was introduced by the teacher;
- Phase 3
- Teamwork was promoted by the recording of an audio file with the storytelling about one of the species by each pair of students;
- Finally, the Augmented Reality application was used.

The augmented reality solution is being produced and envisage to promote student’s authenticity and their emotional reaction towards the application. An aspect considered to be fundamental in order to incorporate and to involve the students work in the final

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AR and not only to use an application with augmented reality, per se as was done in previous research. To accomplish this, a world map was produced and a trigger image was chosen. The trigger image was a treasure chest to increase the student's feelings as an explorer. The images were augmented by using children´s picture and their drawing, drawn in previous classes, followed by a video of the corresponding ocean specie. Drawing were observed after clicking on a student's picture.

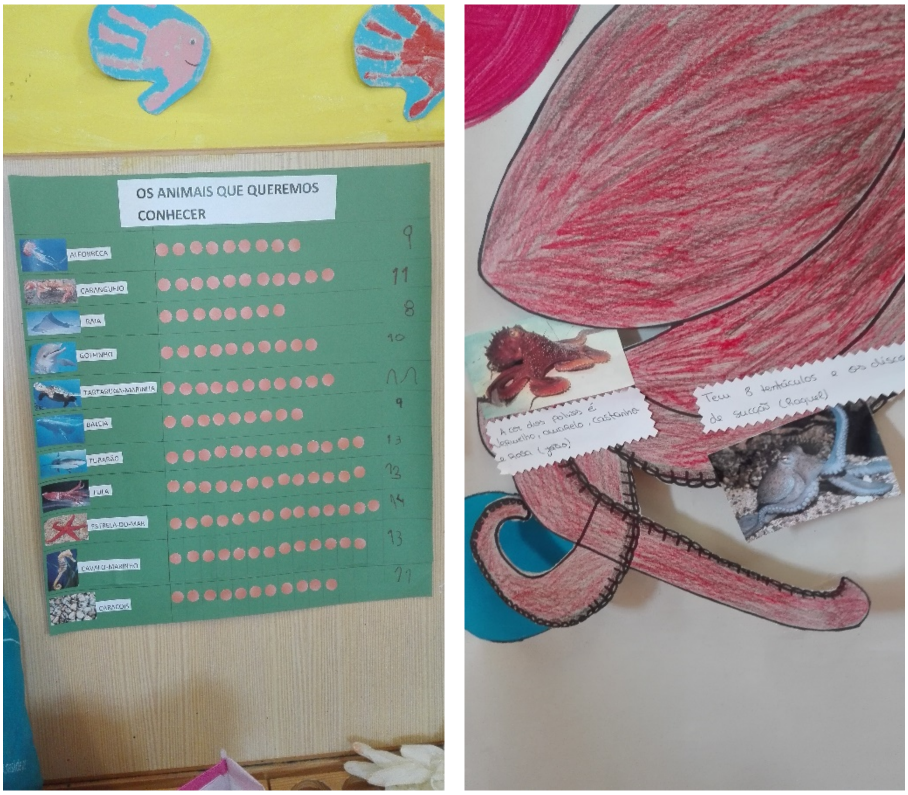

Fig. 1. - Matrix of chosen species and voting results (left) and children draw (right). Source: authors'

Methodologically, the class was split into two groups: one with the more advanced students and the other with the less. The two students with Special Education Needs were grouped into a group of students, characterized as less motivated, shy and quieter. To improve emotional engagement, the overlay image followed the following sequence: student drawing and finally a species video acquired on the internet. Ocean music was played in the background and the experience was developed by each group individually. The trigger image was a treasure chest to conjure an emotion on students that prepared them for a fully immersed adventure in discovering the ocean (Figure 2).

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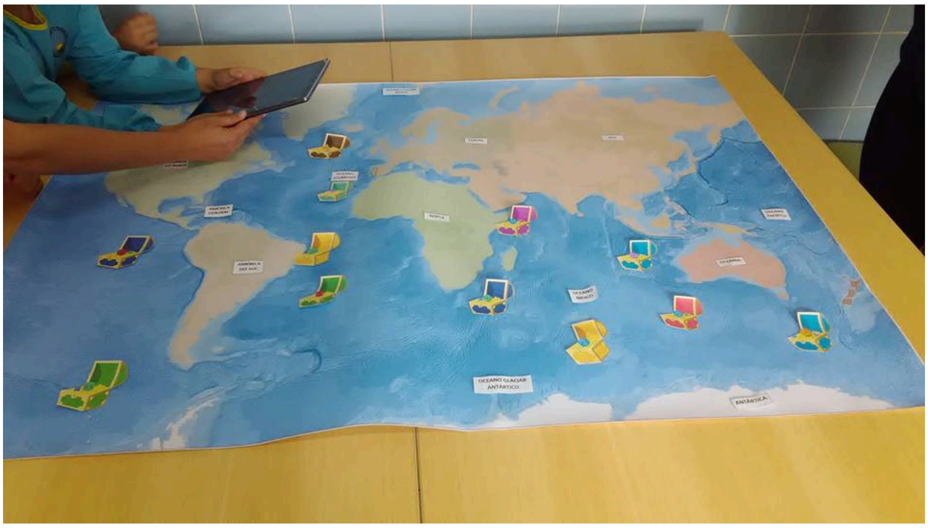

Fig. 2. – Oceans map and Treasure chest. Source: authors'

Researchers, recorded the whole process from the very start, reaching the place, until the end, leaving it. This will be useful to record and analyze emotions, commentaries and barriers during the use of the AR.

4 Discussion

Augmented reality is being acknowledged as an emergent and powerful technology tool and recent results have demonstrated this. At an initial stage, innovative technology immersing students in an augmented reality requires more empirical evidences are required in the educational field. This ongoing research aims to make its contribute in this field. The case study is being applied in a kindergarten with 24 children, aged five. It is expected to be useful, to be of easy usage and analyse the behaviour and attitudes of children with the manipulation of AR applications. At this stage we found that all of the students were curious about what awaited them. When they arrived in the room where the activity was implemented they explored the map and curiously looked at the treasures chest. Researcher´s have summarized the subjects learnt about Portugal's location, the ocean´s and the species studied. Finally, one experience was implemented to show the students how to hold and use the tablet to collect and explore multimedia information. Immediately students waited for their turn to experience and look for the treasure. One by one they used the application and were very enthusiastic, commenting and asking questions about the species. Most of them knew what a tablet was and easily adapted to the application. None of the students needed extra help in order to use the tablet or the AR application. Despite some blips like taking some extra time to upload, students did show nervousness, restlessness or demotivation. They shared the experience and all helped each other. At the end of the experience most of them asked to

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further explore other treasures, demonstrating their taking to the app. Students that were normally very quiet or who felt uncomfortable speaking in front of groups or in the classroom change their behavior, proving to be more dynamic and participative. Frequently they expressed phrases such as, “uauu”, “fantastic”, “amazing”, etc. All the participants found the experience very attractive and enjoyable. They also expressed that the most interesting skill was exploring and manipulating of the app; being an experience they wanted to repeat soon.

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The use of sensors in virtual worlds for obesity control

A case study about virtual/real motivation to encourage self-determination against obesity through the Internet of Things

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Abstract.
Obesity is currently one of the most relevant public health concerns worldwide and may cause several diseases (heart diseases, diabetes, increased cholesterol levels, among others). The successful treatment of chronic diseases, particularly obesity, depends strongly on the participation and engagement of the individual as an active subject of his/her own treatment. The use of the Internet of Things in 3D virtual worlds was studied in the current research as a support strategy aiming at offering to the user the feeling of "being present" in a context specially designed to promote motivation and allow interaction with 3D objects. This article reports part of a qualitative case study that surveyed the impact of the combination of 3D virtual worlds with the Internet of Things and mobile devices as elements capable of boosting motivation in subjects enrolled in an obesity control program. The work was based on the theory of self-determination using extrinsic motivation strategies, with a view to achieving a behavioral change capable of promoting improvements in health and life quality. The analysis of preliminary data confirms that the project has the potential to motivate and encourage survey participants in their weight loss process.

Keywords: Internet of Things, obesity, 3D virtual world and self-determination

1 Introduction

Obesity represents one of the major challenges for public health in the 21st century, with alarming trends in many parts of the world [1], this is an ever-growing problem, according to the World Health Organization [2], overweight can already be considered as one of the major public health issues in the world. The last forecast made by that institution brought alarming data: if the projections are maintained, it is expected that, by 2025, around 2.3 billion adults are overweight and more than 700 million suffer from obesity. With this scenario in mind, the present research was developed with the purpose of investigating strategies to encourage mild and health physical activities with the purpose of losing weight and improving life quality.

This article reports results of the research that used devices currently available within the context of the Internet of Things and the 3D virtual world, based on the theory of

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self-determination in order to boost motivation in the weight loss process, in obese participants. The research project was developed in an environment supported by 3D virtual worlds, with the help of motion sensors. Additionally, conversational agent technologies were also combined, aiming at achieving better results in terms of self-determination among people suffering from obesity problems, who need to improve and/or acquire healthy habits [3]. This study investigated possible technological strategies and their impact on the motivation of obese individuals who participated in the research.

The use of the Internet of Things has been emerging as an accessory in the weight loss process in the current society [4]. Internet of Things is an expression used to define a technological revolution that seeks to connect electronic devices used in the day-by-day (such as household appliances, portable appliances, industrial machines, means of transportation, etc.) to the Internet, which development depends on the dynamic technical innovation in fields as important as wireless sensors, artificial intelligence and nanotechnology [5]. The use of sensors, advanced analysis and intelligent decision-making has been deeply transforming people's everyday lives and many solutions have been arising to help in the weight loss process. Several researches address the use of this technology in helping to lose weight, according to Burke [4], who investigated the use of mobile devices in dealing with overweight or obesity, he believes that a daily feedback message, delivered remotely every day, enhances the weight loss process for participants.

The survey reported herein used the Internet of Things to encourage self-monitoring motivated by a feedback based on Ryan and Deci's theory of self-determination [6], with the purpose of allowing for the weight loss and self-care. Through the communication of a motion sensor with a 3D virtual world (specially designed to boost motivation), which was associated to conversational agents (chatterbots) who use a knowledge base built on AIML (Artificial Intelligence Markup Language) [7]. The knowledge base was set up for the purpose of supporting the sending of motivational messages based on the theory of self-determination and on data produced by motion sensors used by the users, which allowed to customize the extrinsic motivation degree, as well as the approach method [8].

2 Example of the use of 3D in health

Several investigations have shown that the use of 3D virtual environments has the potential to promote good results in terms of enhancements of health-related aspects [9]. In the last decade, immersive environments based on simulators have become a platform capable of recreating the clinic experience in health education. They have a relatively low cost, they allow for a flexible learning process and have a patient-centered approach that promotes engagement in the learning process [10]. According to Brenda et al. [11] the Virtual World has proven, in the last two decades, to be a complementary tool in the assessment of patients with food disorders and obesity, and it is also used for body consciousness purposes in behavioral change situations.

Otte et al. [12] presents a case study on the use of the metaverse to increase motivation for elderly people to become more physical active, connecting devices of the real

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world with virtual worlds, and allowing for the interchange of information through tele transportation of virtual objects in the Second Life software.

Fig. 1. Overview of the study settings. (Left, front view of the system. Right view, back of the system with small and big screens).

The group of participants was made up by four senior citizens, two man and two women with an average age of 63.2 years. They were taken to a room adjacent to the laboratory, and they were not able to see the setting of the experiment. They received a general introduction into the Metaverse Project, which did not tell them about the purpose of the experiment. Participants also filled a small questionnaire to assess their familiarity and experience with sports, then they could ride a stationary bike, which was designed towards a big screen within the researcher's metaverse and a small screen that provided information, as seen in Figure 1. It could be seen that the principle of exchange of information between real and virtual worlds is simple, but the solution is not trivial and requires some programming effort, as well as the definition of a data exchange protocol. From the results of a focus group study, it has been shown that a virtual environment could increase motivation to being more physically active and that users are responsive to a virtual coach.

There is a lot of research on this subject. This article is just an example of another alternate Internet approach to Things with metaverses based on the theory of self-determination.

3 System methodology developed to validate the research

The system was designed to provide support to research activities proposed herein and entails a 3D metaverse environment populated by scenarios built to look like gyms and fitness studios. This virtual environment is peopled by avatars (users) and conversational agents (similar to the user's avatars). These agents were built to interact with the user, both inside and outside the virtual world, supported by a chatterbot system. The system was structured as follows:

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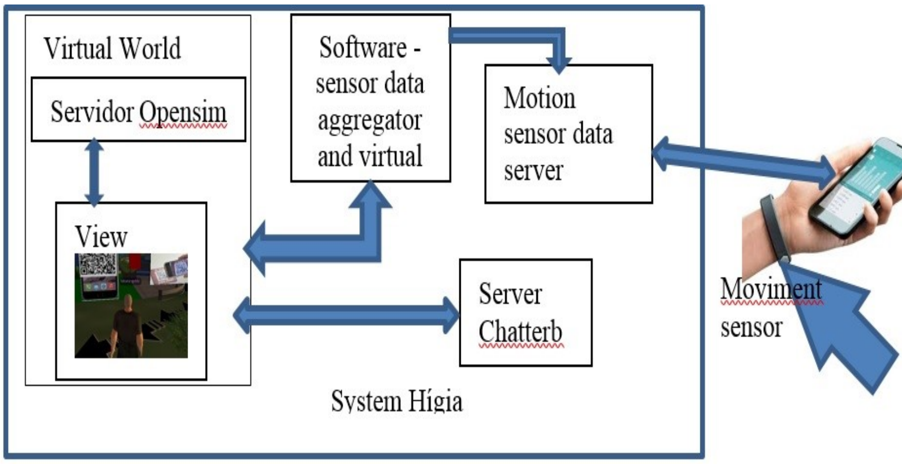

Fig. 2. Flowchart of the HIGIA System

In order to have a functionality between the programmable modules and the agent, it was necessary to define an interaction model, as show in Figure 2 below. The OpenSim [13] server is the 7.6.1 version in standalone mode. That allows the creation of a 3D virtual world to which pre-existing objects created externally may be imported or in which other objects and 3D scenarios may be built or adapted. It allows the registration of users and it may also stablish interconnections with other external systems, such as the SMS system – Short Message Service. The SMS system is used to send motivational messages available in the chatterbot basis and the messages are sent based on the data collected by the motion sensor (this sensor is a type of pedometer, which was used to measure the movement of the participant and after analyzing this data interact through the metaverse and / or the smartphone, in order to motivate).

The access to the 3D virtual world is established by using a client program named viewer. V**iewer** [14] is a software used to access a virtual world to which there are many kinds and manufacturers. This project employed Singularity, which offers better performance and reliability in the rendering of mesh objects, as well as in the animations programmed for the avatars. 3D objects built in environments other than OpenSim, typical of the 3D designing, end up being more complex structures (mesh) that are not appropriately renderized in all the existing viewers.

The sensor data aggregator and the data collector of the virtual environment was implemented using PHP and MySQL. This system may be contacted directly from the virtual world using the functions of the LSL programming language (Linden Scripting Language) [15] and OSSL (OpenSim Scripting Language) [16] used to define the action and reaction scripts included in the 3D objects. There are also features that allow to establish communication with remote systems through the use of Web services, as it was done in the case of the Pandorabots server [17] and with the SMS server (Short Message Service). This server offers a chatterbot service, used to host the knowledge base with the recommendations and answers that the conversational agent used to interact with the participant. These answers and questions are transmitted using a chat

DOI: https://doi.org/10.3217/978-3-85125-530-0-40

window in the virtual world, through which the user's avatar interact with the NPC/conversational agent. The agent was implemented using the Non-Player Character (NPC) feature of the OpenSim. NPCs are entities similar to the users' avatars, however they are computer-controlled.

The above methodology summarizes and explains the methodological steps, it is important to point out that it was necessary to build a functional structure to meet the basic principles of the research, in order to analyze the data received and sent to the mobile devices.

4 Development of the research

The participants engaged in the research were chosen by means of a set of criteria (men, average age of 40 years, self-declared obese and willing to participate in the experiment). The participants firstly came to know, individually, the objectives of the research and how they would participate in the validation of the HIGIA System.

The exploratory research is in development, until the present moment the participation of two subjects was concluded, only the small number of participants, a more daily investigation was carried out during three months of research, combining interviews, self-regulation questionnaire, data collected from the sensor of movement, analysis of all the dialogues occurred in the virtual world, analysis of all messages sent via SMS and the four body measurements (weight and waist circumference).

The research established a spectrum of the variation for a set of factors inherent to the research. The weight of the participants should fall within the same category as proposed by ABESO – Brazilian Association for the Study of Obesity and Metabolic Syndrome, which classification define ranks on the basis of the BMI – Body Mass Index (underweight, normal, overweight, obesity class I, II and III). Additionally, the limitation of devices to be used for monitoring physical activity also influenced the size of the sample (two motion sensors were used). As highlighted by Riva et al. [19], it is important to include in the sampling participants with similar genders and ages, which was also a criterion used in this investigation.

A system was implemented in a 3D Virtual World (OpenSim) with the goal of encouraging the learning of health-oriented behaviors. The system developed was named HIGIA, as an acronym to Individual Habitat and Attitude Interactive Guide (in Portuguese). Pace counters were used as a motivational strategy to engage the research subjects in their obesity control programs. The device records the subjects' activity and their data is then transferred to the 3D metaverse through a connection with a smartphone that initially receives data in each synchronization and then transfer it to the manufacturer's server. Later raw data is retrieved and aggregated, using an API provided by the manufacturer. This data is then treated in the environment directly connected to the virtual world. Information arising from this data feed the messaging routing, giving feedback and suggestions to the user. This information is also presented to the participants as part of the outlined persuasion strategy. A conversational agent was also implemented into the environment. The implementation of the agent uses the NPC (Non-Player Character) feature available in the OpenSim environment. The agent

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(NPC) has the task of guiding the participants through the virtual world using several motivational strategies.

At the beginning of the participation, each person received a motion sensor that was used 24 hours a day and were told to synchronize at least once a day through an application installed on their smartphone. They also had their weights and the measurement of abdominal circumference recorded.

In the first phase, everyone was left with the motion sensor (pedometer) for 1 month, they were instructed to visit and interact with HIGIA at least 2 times a week and perform a task list they received. At the end of one month the participants answered the self-regulation questionnaire and were measured and weighed.

In the second phase of the research, the participants did not have access to the HIGIA System metaverse and continued to use the pedometer and received stimuli via SMS, this phase lasted 1 month, they continued receiving messages from the System and receiving the stimulus from the pedometer (the device Stipulates a goal, that when the user hits and issued a sensory warning). At the end of this month the participants answered the questionnaires and delivered the pedometers.

In the third phase, the participants did not receive direct motivational stimuli, it was a phase to analyze if there was an internalization of motivation, after one month the participants answered for the fourth and last time the questionnaires, where they are measured and weighed (totaling 4 self-regulation questionnaires and 4 measurements)

When starting the participation, each person received a motion sensor which should be used 24 hours a day and should be synchronized at least once a day, through a mobile application. They also had their weights and abdominal circumference recorded. They also visited the virtual world, followed by the researcher who provided guidance concerning the navigation and the use of features available in the HIGIA System.

Fig. 3. – Aerobics class

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In figure 3 we have the avatar of the participant, exercising in an aerobics class, according to Fox et al. [20] this causes a transference of expectations or understanding of behavior from his avatar to his own behavior in the real world.

During the first stage of intervention (which lasted one month), the users could visit the virtual world as many times as they wanted. Thus, they could experience a fitness virtual environment. One of the participants mentioned that "it was the first time that he had ever stepped in a gym". They could also watch videos about methods and ways of losing weight, received tips from HIGIA's System conversational agent and, during the day, they also received SMS messages. Such messages were generated upon the analysis of the sensor's data, aiming at reinforcing behaviors or advising.

Fig. 4. – Season facts and photos

The Figure 4 shows the "facts and photos" season of visual motivation, made up of images and facts of people who managed to lose weight changing habits and leading a healthier life. Here you can find panels, posters, videos and QRCode (pointing to motivational video messages), these materials also contain tips, motivational phrases, small videos, etc. All material was carefully chosen according to the Self-Determination Theory

Another example of motivation, one can cite the avatar figure 5 of the participant, could question the NPC, on matters related to the system.

In the Figure 5 we can see a NPC talking to a participant of the research, in front of a gym, where there are NPCs being active and show examples of physical activities in which the user can engage. The proposal of this investigation is to assess if this kind of virtual example would affect real users, fostering disposition for physical activities

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The conversation between the user's avatar and the agent involves answers emerged from the knowledge database built using the AIML language. The patterns of derived answers and questions were prepared in line with Ryan and Deci's [18] Theory of Self-Determination and with the support of physical education experts and a doctor. All manifestations of the conversational agent/NPC were designed in order to motivate the user to become physically active. Suggestions, tips, recommendations for health improvement in regard of obesity are presented in the dialogues established between the user and the agent (chatterbot). The table below shows a few examples of messages presented to the users.

Fig. 5. Interaction of the practitioner with the HIGIA System

The interaction between the avatar and the agent may take the form of questions made by the users (texts typed to the chat window) when they are in the metaverse. The answers are generated by the chatterbox software based on the content of the knowledge base. For the same question, there is a wide range of possible answers, which are selected randomly to avoid a repetitive reaction pattern.

In Table 1 we have some examples of messages sent to the participant through the SMS of his smartphone and making use of the data received by the sensor the movement.

Table 1. Examples of messages

Objective	Message or media
To show follow-up and monitoring	You have not accessed / synchronized your data for XX days

DOI: https://doi.org/10.3217/978-3-85125-530-0-40

Insufficient level of activity	You haven't reached your goal today, but don't give up, little daily efforts will make you reach your goal and lose weight.
To congratulate good results	Congratulations, it is the second day this week that you manage to reach your goal. You deserve an improvement in your life quality.
To encourage self-care	You are responsible for your body
To offer help, guidance and examples	Let's pursue your goals. Together we can do it. Example of people jogging in the park or exercising in a gym. Motivational videos Short voiceovers with voice synthesizing associated to a character. Animation of NPCs being physically active.

In Table 2 we have examples of dialogues occurring within the metaverse, in the first phase of the research. All the dialogues that occurred in the metaverse of the research, were analyzed, according to the theory of self-determination.

Table 2. Examples of questions and answers

Question	**Answer**
Which drugs can I take to lose weight	There is no secret or magic formula. Get physical Don't give up, reduce your carb intake You should try to eat less calories than you spend in order to lose weight.
How to burn calories	Jogging for one hour will burn 400 calories on average, which equals to a medium slice of lasagna or a medium coke

According to Breckon [21], in order to lose weight, a combination of real and virtual motivation could work better, which was proven in the present investigation that showed a higher amount of body motion and weight loss in this first stage than in the others, where the presence of the virtual world was no longer made available.

The chatterbot's knowledge base is also accessed by the routine in PHP responsible for sending motivational or warning messages through the use of a Gateway with an SMS service. In the present investigation, there is a SMS gateway associated to the Pandora service.

In the second stage (which lasted one month), the participants kept using the motion sensor and receiving the motivational messages via SMS, but they could not interact with the virtual world. At this stage, it was possible to notice a reduction in the amount of motion, but the participants still kept losing weight, although with less intensity than in the previous stage.

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Table 3. Examples of messages sent via SMS

Tips	Answer
Related to tiredness (when the person does not reach the goal)	Excessive intake of alcohol may cause fatigue Inactivity and sedentarism usually cause fatigue
Congratulations for having reached the goal.	Congratulations! You've reached your goal!

In the third and last stage, participants kept using the motion sensor, which provided them information about how they were moving, their body measurements were taken at the end of the stage, but they were no longer connected to the HIGIA system. Measured by a self-regulation questionnaire answered monthly by the participants, motivation was seen to have decreased at this stage. There has also been a reduction in the amount of motion and weight loss was not relevant at this stage.

5 Conclusions

The main contribution of this investigation was to verify the possible contribution arising from the performance of a conversation agent in an immersive world, with external data generated by sensors. It was possible to observe the motivational potential of this kind of resource among obese individuals.

By collating motion data acquired by the motion sensor, we could notice that there was a sharp increase in their daily body motion. An example of the impact of this combination of elements could be perceived through the statement of one of the users, saying that "when I received the message about having achieved my goal, it was an inexplicable joy". That shows an effect arising from the implementation of strategies based on the theory of self-determination. As highlighted in [7], a relevant aspect about practices not intrinsically motivated is how the individuals become motivated to carry them out and how this motivation affects persistence, behavioral quality and well-being. This investigation showed that the elements used, that is, the 3D virtual world, agents and sensors were capable of leveraging extrinsic motivation. The participants went from a state in which they were not motivated to get physically active to a state of personal commitment, although not yet characterized as intrinsic motivation, as once the triggers stopped, there was a reduction in the commitment with the maintenance of the effort to perform physical exercises. According to the theory of self-determination, they would have achieved a stage of controlled motivation, with enforced regulation.

In figure 6, we have a graph that illustrates the data of the two participants of the research.

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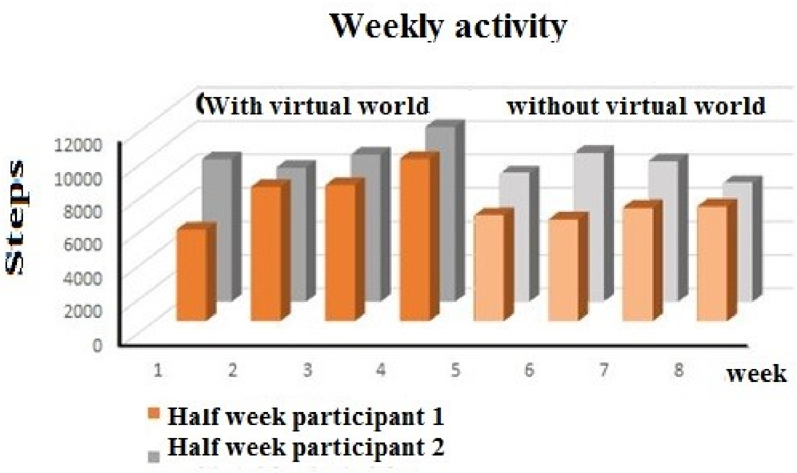

Fig. 6. Graph of number of steps X weeks of two participants

During the time of intervention with the "HIGIA system", there was a great involvement, which resulted in large losses of weight (average of 5 kg in the first phase and 2.5 kg in the second phase) and as we can see in figure 06 an increase of 70% of movement in relation to the usual amount of informed movement (from 1 to 1,5 km per day) by the participants in the initial interview. In this way, the research can prove that given the virtual stimulation, with the non-intrusive monitoring of a sensor and the constant and diversified presentation of motivation, could promote a modification in the search for quality of life.

Thus, the research could establish that given a virtual encouragement, with the non-intrusive follow-up of a sensor and the constant and diversified presentation of motivation, they could promote a change in their search for life quality.

It is important to highlight that, in the second stage of research, there was a motivational decrease that could be ascertained from the data collected from the motion sensor. In the third stage, when the triggers stopped, motivation was not yet internalized [22], which started to reduce the intensity of body motion. That allows us to assume that if there was a virtual gym for individuals aiming at changing their life quality, they would obtain advantages and a significant support if they could use a metaverse with enabling conditions, in addition to associated sensors that could continuously assess those data related to the desired behavior. Each person could, in addition to acquiring their own sensor, which is already a market trend, obtain motivation support from a 3D virtual world, participate regularly in the virtual gym, informing their weight and synchronizing the sensor so they could keep experiencing a positive motivational environment that would enhance their life quality.

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Relaxation Training with Biofeedback in Virtual Reality: Discussion of Wearability

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Abstract. This paper describes a mobile learning app aimed to be used for relaxation training, primarily for adolescents suffering from tension-type headaches. Combining expertise from neuromedicine, psychology, and technology-enhanced learning, we have developed a concept and a working prototype for low-cost biofeedback training applications. The system uses virtual reality technology for delivering visual experience on both low-cost and advanced virtual reality glasses. A wirelessly connected wristband is used to measure user's pulse and adjust the training scenario and the virtual environment based on the heart rate data. The app simulates an immersive environment of a tropical beach with several interactive visual and audio elements. The main goal of the simulation is to make the weather as calm as possible by reducing own heart rate. The progression through the scenario is guided by a therapist's voice with some degree of self-exploration. Repeating the exercise would make the user able to go through the scenario without using the app, learn how to relax, and ultimately combat tension-type headache. The prototype is currently being evaluated in a feasibility study with a small group of participants that answer a questionnaire and interview questions after trying the app. The first evaluation results are presented in the paper. The results are discussed with a focus on wearability – suitable for wearing – of virtual reality glasses and of the wristband.

1 Introduction

Virtual Reality (VR) has been applied to learning and training providing flexible alternatives with immersive simulations of places and activities. This technology can benefit educational process due to low cost, high safety and a sense of presence [1, 2]. Wearable Technologies (WT), such as head-mounted displays and on-body biological sensors,

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can be used as part of VR systems to create additional modes of interaction and feedback.

In this paper, we explore the combination of VR and biological wearable sensors for creating educational experiences. We developed a conceptual framework for designing low-cost training applications that use this combination of technologies. The framework is demonstrated on an example of a prototype app for relaxation training. Relaxation is used in psychological treatment when medication is not an option [3]. Being able to relax quickly is an important skill that is not easy to acquire. Training how to relax is the learning objective of the prototype presented in this paper, while the ultimate purpose is to help adolescence combat tension-type headache, as a part of the bigger project 'Cognitive behaviour therapy treatment of chronic tension-type headache in adolescents in virtual reality', coordinated by the Norwegian University of Science and Technology (NTNU) and St. Olavs hospital, Trondheim, Norway.

Tension-type headache is the second most prevalent of all health disorders among adolescents. Especially chronic headache causes a high burden on the young sufferers. There is no available prophylactic medication in this age group, but biofeedback, a behavioural treatment without known side effects, seems to be effective. Biofeedback is a "process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance" [4]. Presently, this is a highly-specialized therapy unavailable to most people in need. Despite of the rapid development and acceptance of smartphones, VR, WT, and mobile health, there is a lack of literature exploring the delivery of behavioral interventions using these technologies for headache [5].

Our research focuses on an innovative technology in healthcare, aiming at developing and evaluating in real settings a new method for technology-enhanced psychological treatment. The overall hypothesis is that biofeedback in VR is effective and tolerable for the prophylaxis of chronic tension-type headache in adolescents, and that it can be self-administered by patients at home. The hypothesis has not yet been verified. The prototype we have developed is being evaluated in stages. In this paper, we describe the system design and present the concept behind it. We also present and discuss the first evaluation results related to the wearability aspect.

2 Background

Learning to Control Body Reactions: Psychological Treatment with Biofeedback

Psychological treatments are designed to alter processes underlying or contributing to pain, distress, and/or disability [3]. Such treatments can be an alternative where there are no effective prophylactic medications, for example, in treatment of chronic tension-type headache among adolescents [6]. Psychological treatments were originally developed for delivery in the clinic in a format in which the patient and therapist work face-to-face [7, 8]. This requires trained personnel with special resources in multidisciplinary settings which are unavailable to the absolute majority of persons in need. Hence, there is a need for self-administered and easily accessible technology.

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Mobile Health applications (mHealth apps) handle various medical or health issues using mobile devices [9]. This is a new innovative field, and its greatest potential is in chronic diseases that are highly prevalent, because the mHealth apps improve access to health care and can deliver therapy experience that would be impossible to create otherwise. In addition, there are now several wireless, wearable body sensors which can measure, bodily functions with reasonable accuracy and precision [9, 10].

Biofeedback method has been used in healthcare since late fifties and gained popularity in the recent years with the availability of bio sensors and mobile technology [11]. It improves psychological treatments, allowing patients to learn how to voluntarily modify their bodily reactions through the feedback from their own physiological processes. The most frequently used modalities are electromyographic activity, heart rate, and peripheral skin temperature [12]. It is generally considered that this reduces the excitability within central nervous system networks and renders individuals more resilient to effects of environmental stressors [13, 14].

European treatment guidelines conclude that biofeedback has a documented effect for tension-type headache patients as a group [15]. Biofeedback is generally claimed to be efficacious [12], with a larger effect in children and adolescents than in adults [16].

Perception and Sensing: Virtual Reality and Wearable Technologies

VR simulates spaces, objects, humans, and activities that can reproduce a precise image of the reality and simulate required settings [17]. VR technologies provide fresh perspectives to healthcare and great potential supported by several examples of documented positive effect [18-20] but still with room for improvement [21].

Although, VR systems offer different interaction modes, the recent popularity and attention has been generated by VR glasses, after Oculus Rift released their first device in 2013. VR glasses is a type of WT devices that is worn on the head and has a display in front of the user's eyes [22, 23]. Most of these devices contain a tracking system, which allows much greater immersion, as the user can control the direction of the view in a virtual environment in exactly the same way as in the physical world – by turning the head. Modern desktop-free human-computer interfaces increase the value and transferability of virtual experience.

Other types of WT devices include wireless body sensors that can measure, for example, heart rate with reasonable accuracy and precision [9, 10]. The WT sees, hears and perceives the user's physical state. Wearable sensors bear potential to capture the key aspects of human performance during a learning activity. This can allow analysis and reflection upon the activity, individually or collaboratively [24, 25]. Capturing human's psycho-physiological states using bio-signals and physiological phenomena is at the core of perceptual technologies [26].

Both VR and wearable sensors contribute to increasing immersion of the user.

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3 Training with Virtual Reality and Biofeedback: Concept Design

We are designing an overarching conceptual framework to facilitate future development of VR applications for therapeutic purposes, especially in pain coping and relief. We have identified the following major VR mechanisms for pain coping and relief:

- **Distraction**: drawing attention from the patient's mental pain processing with immersive and interactive VR experiences, for example, SnowWorld for burn victims [27].
- **Relaxation**: immersing users in relaxing simulated virtual situations and places, suitable for meditation and mindfulness, for example, Guided Meditation VR (https://guidedmeditationvr.com/).
- **Illusion**: manipulating sensory brain input (visual, haptic etc.) in order to manipulate experience of pain, for example, providing false visual feedback of head movement to people with neck pain alters onset of movement-evoked pain [28].
- **Imagery skills for pain control**: controlling pain by manipulating a visual representation of pain experience (in 3D/VR), often with bio- or neurofeedback, for example: manipulating stereoscopic geometric shapes (with mouse), each of them corresponding to a certain type and intensity of pain.
- **Physiotherapy**: enhancing traditional training in a variety of physiotherapeutic situations with VR, for example, VR training for patients with neck injuries [29].

We have also developed a VR characterization framework with features and elements along the dimensions of User/Patient, Virtual Therapy Place, Therapy artifacts and Interface. The design concepts and scenarios for specific therapeutic goals and situations in the context of Cognitive Behavioral Therapy and biofeedback goals, such as relaxation, sleep strategies, and coping, [30] are developed by matching the VR pain mechanisms with corresponding VR features and elements.

Biofeedback and wearable interaction [31] are the central concepts of the framework (Fig. 1). The user (on the left) wears 3D glasses and a headset to perceive the VR experience and a wearable sensor that measures pulse. The user exercises relaxation and tries to control his/her heart rate. The wearable sensor (bottom) measures the pulse of the user and sends it via Bluetooth to the wirelessly connected PC or mobile device at the constant requests coming from the VR app. The VR app (right) receives the pulse data in real time, updates the features of the VR environment based on these data, and renders the VR environment accordingly. The head-mounted display (top) receives the images and sounds and delivers the VR experience back to the user.

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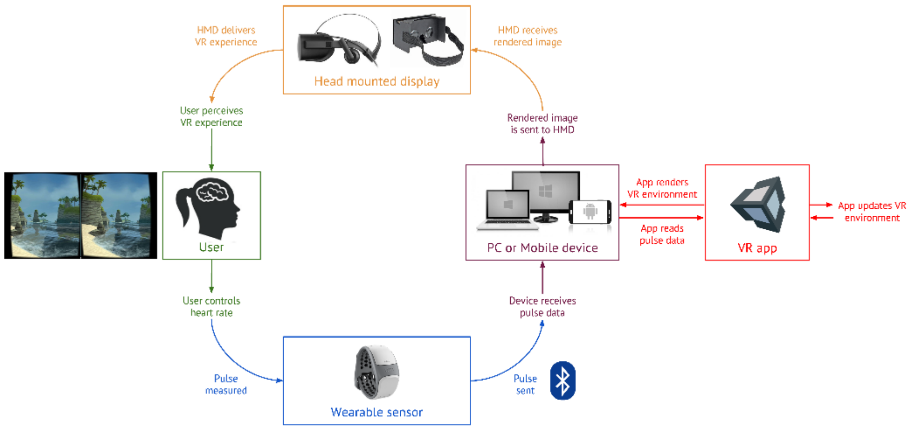

Fig. 1. Conceptual design and biofeedback

The framework is designed to support mobility of the users. It should be possible to create applications that can be used in treatment programs in and outside of a clinic. This is reflected in the hardware setup. The applications should run on the advanced VR glasses, stationary PCs, and read data from highly accurate sensors. At the same time, the applications should also run on smartphones, cardboards, and consumer wristband sensors. In addition, the domain of scenarios we focus on (relaxation, coping, imagery skills) assumes that the user is comfortable while experiencing the simulation. Therefore, the wearability aspect is addressed in the design and evaluation.

In our technological setup, both the heart-rate sensor and the VR glasses are wearable devices. Wearability plays an important role in the users' comfort and quality of experience, but often is not been taken into consideration in studies [32]. The discomfort may be caused, as defined in [32], by low wearability (e.g., device gets in the user's way of activity) and strange appearance (e.g., devices attached to the body with a band, tape, cap, or wig). Several additional factors that affect wearability include functionality, application task, system management, maintenance, economic sustainability, interoperability, style, fashion, and branding. These factors can be applied to the design, selection, and placement of devices.

4 Prototype Design

Scenario

In the current version of the prototype, the user only has access to a single test-module of the virtual environment that implements a tropical beach scene and a relaxation training scenario. The virtual environment contains two types of elements: static and interactive. The static elements are decorations that are added to create the right atmosphere

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defined by the scenario. The interactive elements change depending on the user behavior, heart rate and gaze direction. For example, sea waves gradually become higher when the heart rate of the user increases and vice versa (Fig. 2). A set of 26 sound instructions is included in the simulator to guide the user. The instructions are not given linearly one after another, but triggered depending on the user's progression in the scenario.

Fig. 2. Environment changes: lowest heart rate (left) and highest heart rate (right)

The goal of the exercise is to make the sea as 'calm' as possible, where the threshold value for a 'calm' sea is adjusted/calculated individually from the starting / baseline heart-rate value. The session ends when one of the following conditions is met:

- The threshold value for the 'calm sea' has been met (baseline value - 20%)
- The absolute heart rate is lower than 30
- The threshold value for the 'stormy sea' has been met (baseline value + 75%)
- The absolute heart rate value is higher than 120
- The maximum time of the session has elapsed (10 minutes)
- The user chooses to end the session

Architecture

The current version of the prototype has a simple modular hardware / software architecture (Fig. 3). Main VR scene is a central software element that is present is three different user applications: advance VR app (version for Oculus Rift and version Gear VR), desktop app, and a mobile app (with two modes: for a regular screen and for Google Cardboard or similar). Depending on the platform, the main VR scene uses Java or C++ modules to read the pulse data from the wearable sensor and update the 3D environment and the scenario.

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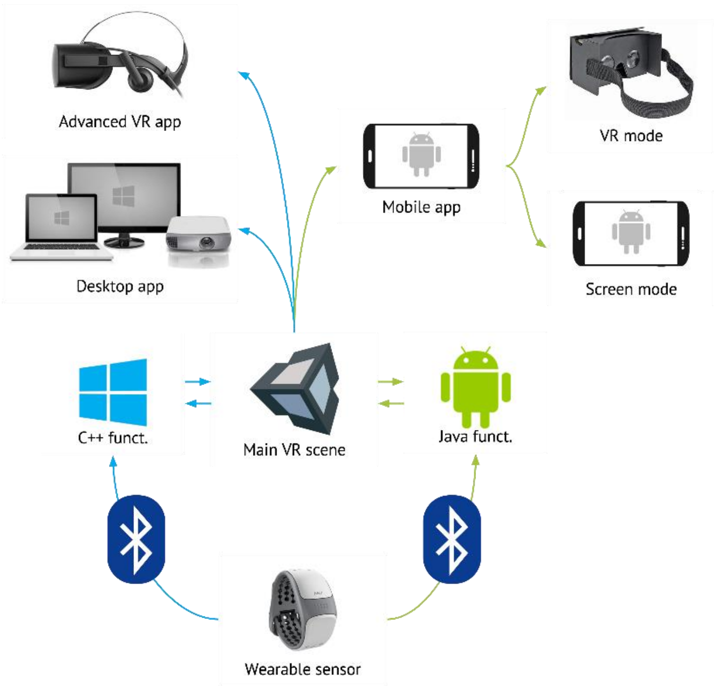

Fig. 3. Hardware / software architecture of the prototype

5 Evaluation

Settings

We started the technical feasibility study by demonstrating the prototype to a group of 84 last-year high school students (with a few older people in the group) in September 2016. All of them volunteered to test the simulator. A special version of the Mobile app gave each participant one minute to relax immersed in the virtual environment and displayed the results. We tested the overall impression of the target group participants, comfort of using a wearable sensor and 3D glasses, and the observed general trends in their heart rates. We did not collect any personal data (e.g., name, age, photo), but asked briefly about the general impressions. The app also recorded four heart values for each participant: at the start of the session, at the end, maximum, and minimum.

Next, a more detailed evaluation has been conducted with 13 volunteer subjects in 13 individual test sessions conducted in November 2016. The following procedure was used with each participant:

1. The evaluator briefly introduces the subject to the study and hardware devices, but not to the logic in the simulator.
2. The subject tries to use one of the prototype apps (VR app or VR mode first, when available).

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3. The subject tells the evaluator what he or she understood and felt while using the simulator.
4. The evaluator explains to the subject the logic and the rationale behind the simulator features.
5. The subject tries out the prototype app(s) again (the same or different app and/or mode). All the subjects tried at least one prototype app, while some tried two or three apps or modes.
6. The subject fills in the questionnaire.
7. The evaluator interviews the subject using open questions, filling in short notes.

As the evaluation sessions were conducted in different locations (local events and meetups), different apps of the prototype were used. Some subjects tried the advanced VR app and the mobile app in the VR mode, some other tried the desktop app and the mobile app in the screen mode, and in other combinations.

The questionnaire contained four background questions, three general Likert scale questions, seven design-and-functionality Likert scale questions, and nine relaxation-and-biofeedback Likert scale questions. The semi-structured interview contained six open questions. Questionnaire data was analyzed without using statistical methods because of the aim to reveal general impressions and the small number of subjects. The interviews were not recorded for full transcription, but instead captured in notes. The notes were then grouped by questions and qualitatively analyzed. In this paper, we present the results that are related to the comfort of use, biofeedback and wearability.

The main project 'Cognitive behaviour therapy treatment of chronic tension-type headache in adolescents in virtual reality' has been submitted for approval to the Regional Committees for Medical and Health Research Ethics. According to the Ethics Committee, the feasibility study part of the project does not fall under medical and health research and hence does not need specific approval. Since no personal information has been collected (such as names of the participants), it was not required to seek approval from the Norwegian Centre of Research Data, either.

Results

The results of the test conducted with 84 participants in September 2016 demonstrated that the target group subjects are generally very interested in both VR simulators and WT devices. All the participants agreed to wear the sensor on their wrists and all understood how to use the cardboard 3D glasses. Not everybody gave an explicit feedback, but those who did overall enjoyed the experience. The great majority of the subjects 83 out of 84 did not have any difficulties preparing to and going through the relaxation session. Only one participant could not complete it because of a difficulty wearing the cardboard.

The logs collected by the app allowed us to better understand how quickly the heart rate of the participants of this age group can change. The diagram below features the pulse change as measured by the wearable device. On the horizontal axis, the values for each participant are given sorted by how much they relaxed (Fig. 4). The values vary from the pulse values decreasing for 37.3% (Fig. 4, left) to increasing for 57.4%

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(Fig. 4, right). The number of participants who managed to relax (heart rate in the end of the session is lower than in the beginning) was 61 out of 84.

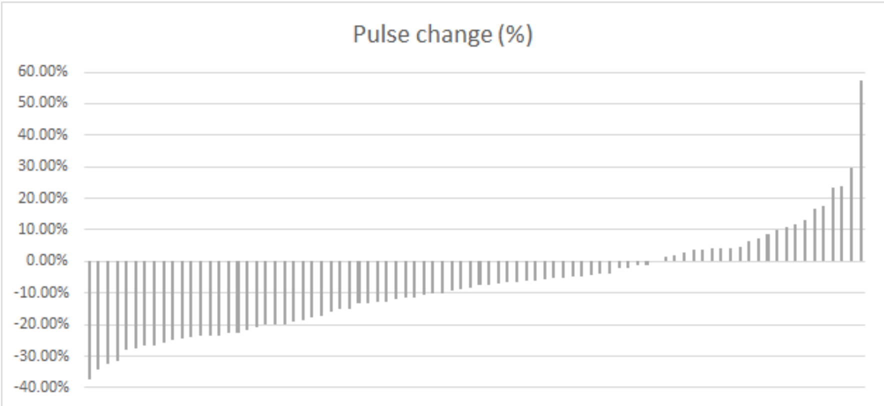

Fig. 4. Pulse change from the start to the end of the session

The technical feasibility study provided more detailed feedback on specific components of the simulator. The target group consisted of 13 subjects who were older than the target end users of the simulator. Their age varied 22 to 46 (average 28,9). Even though the feedback data was affected by the age, it allowed us to conduct detailed interviews, try different versions and different devices and discuss different aspects of the simulator.

The questionnaire contained a specific question if it was physically uncomfortable to use the simulator application. All who rated the advanced VR version (with Oculus Rift) responded that it was comfortable to use the simulator. The majority of those who evaluated the cardboard version were also comfortable, but two participants responded that it was uncomfortable and very uncomfortable. The interview data gives a much deeper insight to the issue.

The interview did not contain specific questions about wearability or comfort of use, but several questions where these aspects could be brought up as issues. Five out of 13 participants pointed out wearability and comfort as important aspects, and for three of them these issues were the most important factors affecting the experience.

When describing their general impressions, three participants reported that it was physically uncomfortable to wear 3D glasses. All these three participants tried the cardboard version. The issues discussed included the difficulty setting up and adjusting the 3D glasses and the cardboard being generally to wear for a period of time. Another issue was related to the extreme focus on the VR simulation that cuts off the peripheral vision, which could negatively affect relaxation. One participant discussed distraction of the relaxation process caused by virtual elements. As many people slightly bend down their head when trying to relax, they would gaze at the waves in the simulator, not seeing the horizon and the sky, while the reflections on water might look too distracting. Moreover, some elements of the virtual environment, such as the therapeutic

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instructions, are asking the user to pay attention to certain elements of the virtual environment, which requires to look up.

Interview note: "*I saw reflections on the waves, they distracted me. It was difficult to control the balloons, because I needed to change my position and look up.*"

When discussing how the simulator can help users to relax better and then how to make it more user-friendly, two participants suggested to take care of the comfortable physical environment. The user should be instructed and should have access to a comfortable place to sit (e.g., an armchair), and the wearable devices should not prevent the user to be in unnatural positions. For example, the 3D glasses should not be held in hands, but adjusted with a strap, and it should be possible to adjust the lenses. One negative consequence was identified in testing with two participants, when the wearable sensor could not measure pulse for some time (while the participants were moving actively trying to find a comfortable position). This led to scenario development not corresponding the actual heart rate of the user. For better relaxation, one participant mentioned that the simulator should give an option to close eyes to use imagination for further visualization of the scenario.

6 Discussion and Conclusions

The results demonstrate that wearability and comfort are indeed very important for the users. The issues of low wearability were considered more important for relaxation with VR than strange appearance [32]. Utilizing the main functions of the wearable devices without being obstructed was the most important factor in the presented evaluation. The wristband measuring pulse was found easy to wear and comfortable, but possible malfunctioning (failure to read pulse) was sometimes difficult to spot immediately. 3D glasses caused several issues, especially the cardboard. At the same time, the function of 3D glasses was critically important, and the advanced VR glasses (Oculus Rift) did not cause as much discomfort.

The evaluation of the first prototype demonstrated that wearability and comfort are not only important for some users but should be considered as central design features for relaxation and psychological treatment simulations. As the VR environment affects the user in the physical world (by visual cues or sound instructions), it changes posture and the hear movement of the user, and therefore affects the heart rate. Therefore, it should be considered when designing a scenario and the interactive elements.

The instructions and user guidelines should include the setup of the physical environment (comfortable chair) and describe the correct posture. The importance of such instructions increases in individual use outside of the clinic setting.

An important aspect that was not evaluated in this paper is the use of the simulation by a person that is experiencing headache. As our main target group include young people with relatively frequent headaches, special instructions should be given for such situations.

The major contribution that we anticipate in this project is in using VR and WT to direct patient's attention and help to control his/her psychological state during therapy in ways that support stimulated recall of experiential learning.

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Special Track: Serious Games using Immersive and Assistive Technologies

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Training teachers to employ a digital art history curriculum: An evaluation of the Crystal Bridges mixed distributed and virtual reality professional development

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Abstract. Rural students may lack access to equivalent art content and resources compared with their urban peers. In this study, a museum of American art partnered with a private contractor, university, and online course provider to create two online art courses for high school students - on art appreciation and studio art. The courses use ArtSpace, an online art portfolio tool, ArtChat, a tool that allows for synchronous and asynchronous discussion around a specific piece of art, and Gallery 5, a 3D immersive museum gallery. Professional development for teachers using the courses was evaluated using semi-structured interviews and focus groups. Results focused on teachers' depth of art experiences, the digital tools, and the collaborative experience of being learners within the museum.

Keywords: Art · immersive · unity · rural

1 Objectives and Purposes

While, many K-12 schools face continued budget cuts as well as reduced time for the arts in the face of time needed to prepare for high stakes standardized exams [1]. While advanced placement exams in art history are available, many rural districts lack the financial and physical resources to adequately support those efforts or even art in general. This means that students cannot visit large cities that are often three hours from a rural school district to experience the art museums and physical works they discuss in preparation for exams or even in introductory art history or appreciation courses.

Beyond putting these children behind in terms of preparation for exams and future work in areas of digital literacy, digital art, and other professions, this limits student growth on the exams that states now prioritize. Research in recent years has explored the relationship between art exposure in museums with improvements on standardized exams [2, 3].

As a result, rural students may have a disadvantage versus their urban peers in terms of access to equivalent content and art resources. Continued decreases in art education mean these gains cannot be realized without help.

One approach to overcoming the rural-urban divide that separates many learners from experiences with arts has been to use online resources and tools. Artsy and others now provide access to artworks from museums around the world, as well as curricular materials to

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help teachers guide students to thinking about art, including appreciation and knowledge of historical contexts. The tools can also provide video that shows expert views and critiques of art within global context, as well as simply provide access to a world they are too far away from to experience in person.

Some museums are seeking to address this inequity in rural-urban access to art education. In this study, Crystal Bridges Museum of American Art partnered with the Educational Development Corporation, the University of Arkansas, and Virtual Arkansas, the online provider for the state of Arkansas for public school students. Two courses were authored for high school students - one focusing on art appreciation and another on studio art. In the first course, *Art Appreciation and the American Identity*, students make connections between art, history, and identity, and they practice and apply the skill of curation to create two online exhibits: one about their individual identity and one about the American identity. The second course, *Art + Process: Creating a Body of Work*, explores the works of several contemporary artists working with a variety of techniques, with a final goal of experimenting with these artists' techniques, ideas, and concepts by creating original artworks. Both of the courses include custom learning objects, engaging, hands on assessments, and extensive use of Gallery 5, an immersive, 3D online experience in which students curate their own art collection. Gallery 5 will be the main focus of this presentation.

Both courses were rolled out for use in Fall, 2016 by approximately 25 teachers in the midwest/midsouth region of the United States. Teacher training for the courses was performed at Crystal Bridges Museum of American Art in Bentonville, Arkansas during Summer, 2016. This proposal describes a mixed methods evaluation of the teacher training's objectives, materials, process, and outcomes.

2 Framework

Both courses use a social constructivist instructional model [4] that emphasizes a visible thinking conceptual framework. The Visible Thinking initiative began as a way to develop a research-based approach to teaching thinking dispositions. The approach emphasized three core practices: thinking routines, the documentation of student thinking, and reflective professional practice [5]. Applied to these two courses, it coalesces in an artful thinking approach that emphasizes the development of six thinking dispositions: Comparing & connecting, exploring viewpoints, finding complexity, observing & describing, questioning & Investigating, and reasoning [6]. Each work of art has primary, secondary, and multimedia source materials that include essays and videos. Throughout the courses, videos with Crystal Bridges staff and original artists also unpack the curatorial and exhibition process. The courses also use ArtSpace, an online art portfolio tool (see Figure 1) and ArtChat, a tool that allows for synchronous and asynchronous discussion around a specific piece of art.

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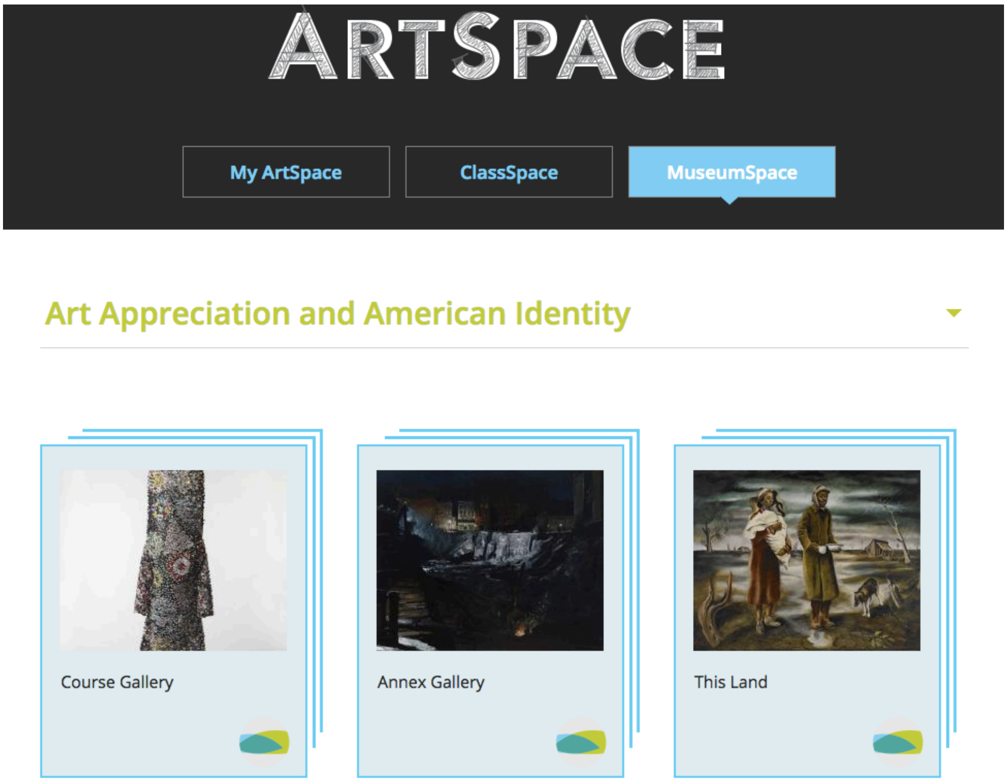

Fig. 1. Art Space ePortfolio tool for students to curate their own collection of artwork.

They also employ Gallery 5 (shown in Figure 2), an immersive three-dimensional interactive "blank canvas" rendering of one of the museum's galleries.

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Fig. 2. Gallery 5 Introduction screen displays an external view of the Crystal Bridges Museum of American Art.

Using game engine Unity3D, this virtual gallery application was created by staff and students from the Tesseract Studio for Game Design and Immersive Environments at the University of Arkansas. This tool allows students to create multiple gallery projects and share them with fellow students and their teachers.

3 Course Navigation

The courses employ a point and click navigation using a standard, left hand navigation menu to access specific lessons and a tool palette to access ArtSpace, ArtChat, and Gallery 5. However, due to the nature of the immersive environment, Gallery 5 is different. How can teachers move around in the space? How do they arrange and rearrange artworks? The environment utilizes a three-quarter overhead perspective, common in real-time strategy games, permitting users to zoom in and out and pan the camera view. A map of the museum space is on the left of the environment allowing teachers to see where they are from a big picture perspective and to instantaneously "jump" to specific places in the museum gallery.

To place a piece of art, teachers access a drop-down display of mini-artworks and can choose specific works of art and click and drag it onto the 3D gallery walls (see Figure 3). Teachers can also describe each piece of art by typing text about the artwork and positioning it around the piece. An eye-level guide is also available to aid users in determining where to place artwork compared to a person's average eye level. A walkthrough mode permits users to virtually walk through the gallery and experience their art collection in first-person view, and

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adjust the placement of the paintings (see Figure 4). Teachers can also manipulate lighting in order to best display their art (see Figure 5). The end result is a curated collection of art for the teacher or student to display (see Figure 6).

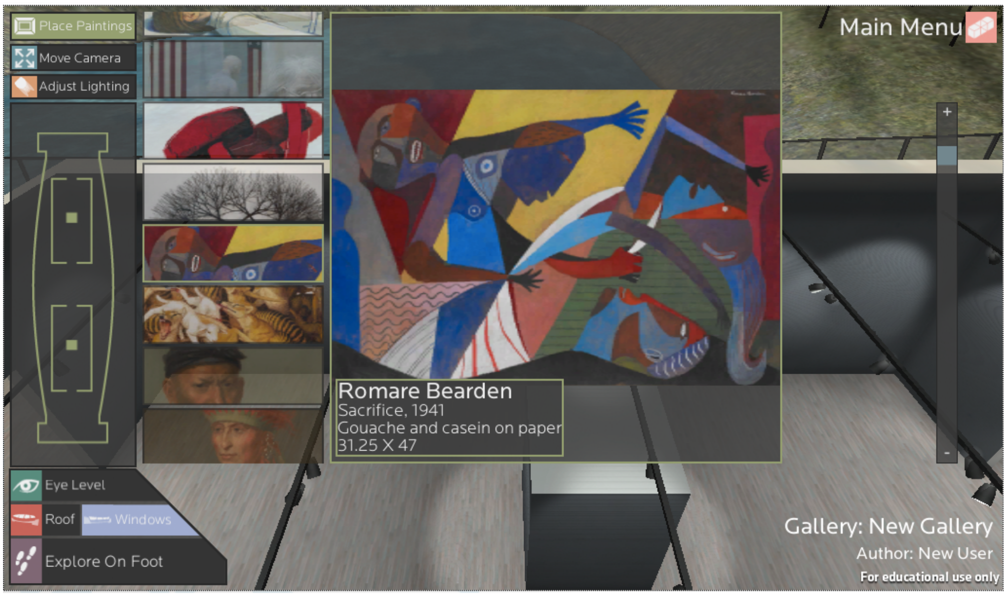

Fig. 3. Gallery 5 Place Painting screen where students can choose from many different artworks from the collection at Crystal Bridges Museum of American Art.

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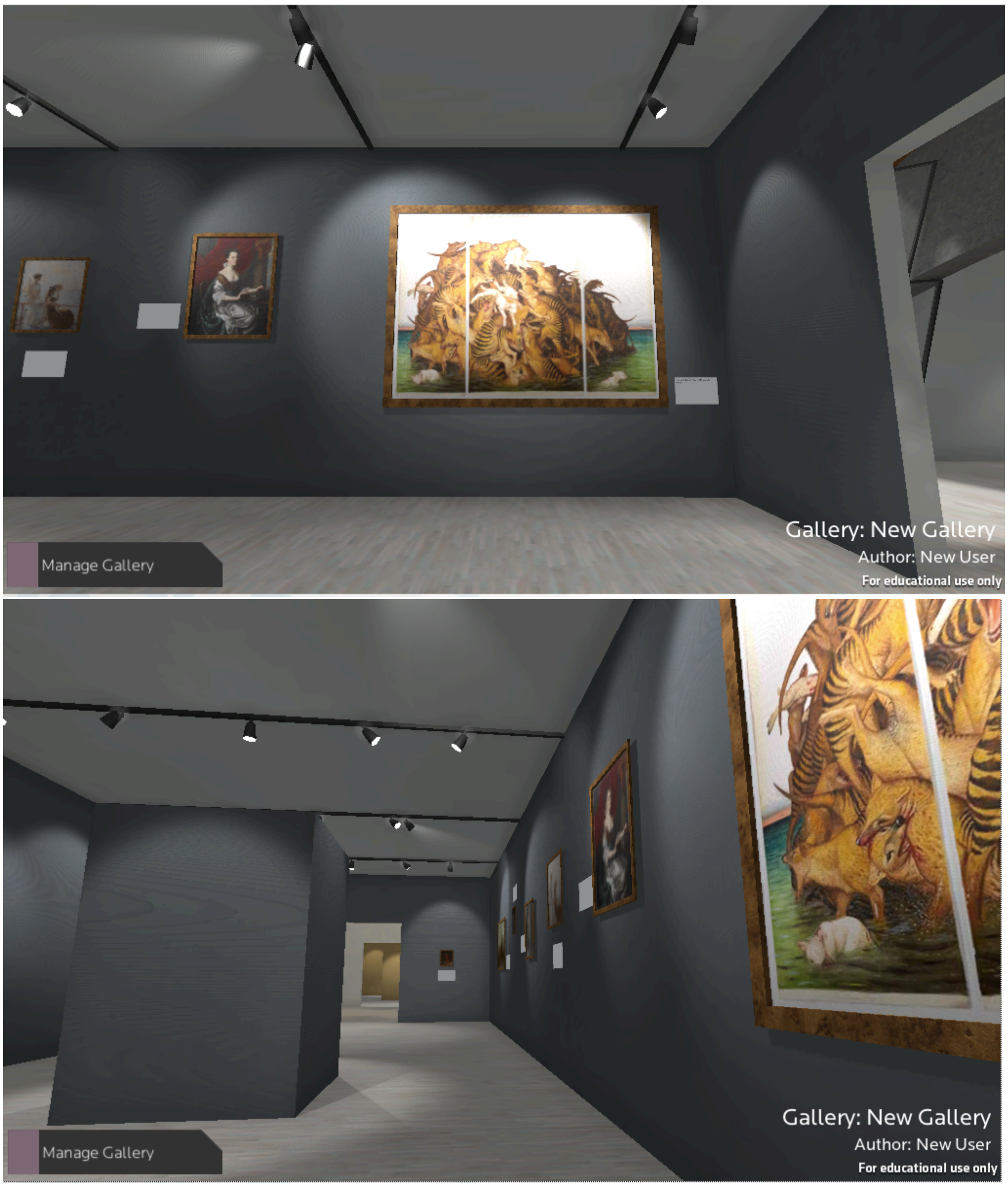

Fig. 4. The Explore on Foot feature of Gallery 5 allows students to explore their own or peers' art collections and provide critique.

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Fig. 5. Gallery 5 Adjust lighting tool allows students to manipulate lights in order to highlight specific works of art.

Fig. 6. Student curated collection of Crystal Bridges' Museum artwork.

4 Methods

Semi-structured interviews and focus group discussions were conducted and recorded during the onsite training. The focus group was scheduled during the first day of the training and was attended by five teachers. The interviews were attended by 14 teachers, three employees of the Educational Development Corporation, and the Director of Education and research in learning at the museum. The interview and focus group questions were synthesized from technology in education usability protocols related to teacher professional development.

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Pre and post test data was also collected to provide basic demographic information as well as limited evidence of effectiveness.

After transcribing the focus group and interview audio files, the transcript was reviewed by the researchers to ensure accuracy. The constant comparative method [7, 8, 9] was used to code the interviews, focus group, and pre and post test data. To do this, we developed an initial codebook, which included the code, a definition of the code, and guidelines for using the code. Our goal was to achieve categorical saturation, a technique suggested by Lincoln and Guba (1986). A confirmatory analysis was also conducted through three rounds of coding. A pretest survey was also administered to students during the first few weeks of the course. The survey contained 24 questions, 5 of which were open-ended text entry. Nineteen teachers completed the survey (86.4% response rate). A posttest survey was also administered the week after the training containing 14 questions, three of which were open-ended text entry. Nineteen teachers completed the survey (86.4% response rate).

5 Qualitative Results

The interviews we conducted with teachers regarding the training resulted in a number of outcomes related to their perceptions of the training to use the digital museum curriculum. Some focused on their experience with the depth of materials presented by the trainers, while others related to the digital tools, and still others focused on the experience of a learner within the museum itself with a group of collaboratively minded teachers. Each of these are described briefly below, to be expanded on in the presentation.

5. 1 Rich curricular materials

The teachers described the museum curriculum materials presented in the training as having “lots of depth, context, and historical explanation,” as one teacher with more than 20 years in the classroom described. In nearly all of the interviews, the connections made within the digital tools presented in a proprietary Moodle and Drupal content management system were praised for their value to help students think. Further, they felt that the trainers provided strong hands on activities that helped model the teaching approaches they should use with their own students, whether in the classroom or using synchronous online communication tools. However, they asked for more time to practice the associated art skills associated with the materials, because that time helped them uncover issues they would face in their own classrooms.

5.2 Teacher concerns from the training regarding local classroom use

Teachers believed that additional time would further help them develop strategies for coping with any differences between how the digital products worked during the training and how they would likely perform in their own rural classrooms. In their home districts and buildings, they reported that it is likely that the Internet speeds are slower, connectivity issues abound, and the machines are perhaps not as robust as those in wealthier, suburban school districts. There were also some concerns from those that taught fully online about whether or not they would be able to troubleshoot some of the products, especially the *Gallery 5* virtual world space.

5. 3 The virtual world’s high system requirements

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During the training, the teachers explored the *Gallery 5* immersive space with help from its lead developer. The immersive environment acts as a simulated, real-world context and its purpose is to situate student learning about art curation. There were difficulties observed by the researchers and reported in interviews and focus groups by the teachers. These tended to stem from computers that were sometimes locked down by their districts, so they could not install plugins for Firefox to allow the virtual museum space to load. Other teachers found their batteries expired quickly and a lack of power strips available in the room exacerbated the problem. Three of the twenty two teachers could not actively participate in the training activity and therefore did not receive the full training. Some suggested that in the future, trainers should provide a checklist for what they need to have access to on their local computers as well as a sample computer with comparable specifications to what their students might use to test at the training to ensure it can meet the requirements of the digital products.

5.4 Administrative and technical outcomes and concerns

A need for preparation before the training was one area the teachers highlighted in the interviews. When they arrived, the first day much time was devoted to having teachers develop logins for multiple systems including the content and learning management systems. Some expressed frustration at not having a single sign on for all systems and at having not done this technical administrative work a week or two before. Not knowing what they would need to have prepared to participate in some of the activities was a also a challenge for some instructors. For example, one learning activity required that teachers have personal photos to use, but many did not have access to their photos at home, sometimes because their work laptops locked out access to their Facebook pages if they had them, or they simply did not have an online photographic presence to draw from at all.

The classroom where the training was held was a large classroom used by the museum for presentations and instruction. The teachers were pleased with the technology available and used to deliver the training, which included high powered projectors and a central presentation computer, movable desks and chairs to allow for collaboration and art creation. The room included pinboard walls to post sheets of paper that collected student work. For the first three days of the training, there were no power strips for the teachers to plug in their laptops. Given that this was a bring-your-own-device (BYOD) training, this was a challenge for teachers because their batteries would die at different rates, though very few made it through the training day with any charge, making participation in online activities difficult or impossible. Further, some had brought tablets such as iPads, which did not meet the needs of the online curriculum, with some components requiring Firefox add-ins that do not yet exist. The technical issues and technology in general were explained by one participant, though heard from many, as “the big concern is the tech...adding a virtual classroom and helping kids navigate at a distance.”

5.5 Learner excitement about process and products

The learners were especially excited about the modeling of teaching that they would do in the future because they took a learning by doing approach where they stepped into the shoes of the students. One example that the group especially appreciated from a Florida teacher is shown in Figure 7.

DOI: https://doi.org/10.3217/978-3-85125-530-0-42

Fig. 7. Sample teacher artwork created at the training.

This process allowed the teachers to understand better how to teach based on their own experience and project how they would have to prepare to teach in their own classrooms.

In addition to making artworks that would be used in the fall version of the course as models, the teachers enjoyed developing strategies for teaching their individual students, often compiling them on large blue sheets of paper or notebook paper as seen in Figure 8.

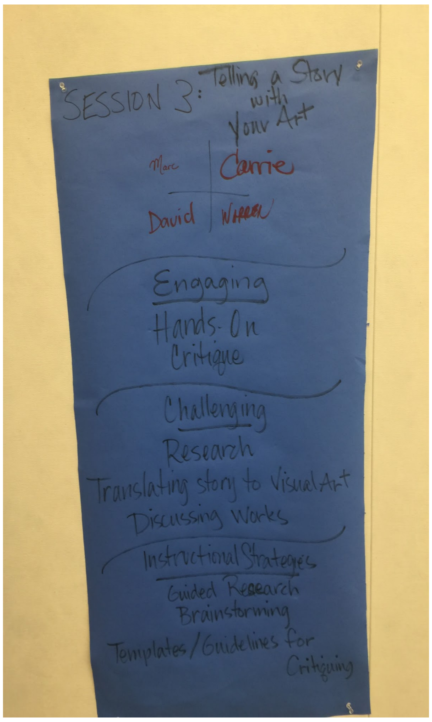

Fig. 8. Example session outcome with strategies developed by the teacher participants.

This strategy construction process was often done through group-based tasks in which the teachers constructed their own intersubjective agreements about appropriate outcomes they would expect in their courses. They were also given the opportunity to provide the developers with feedback in the form of a wish list that included what they would like to see in future iterations of the curricular product shown in Figure 9.

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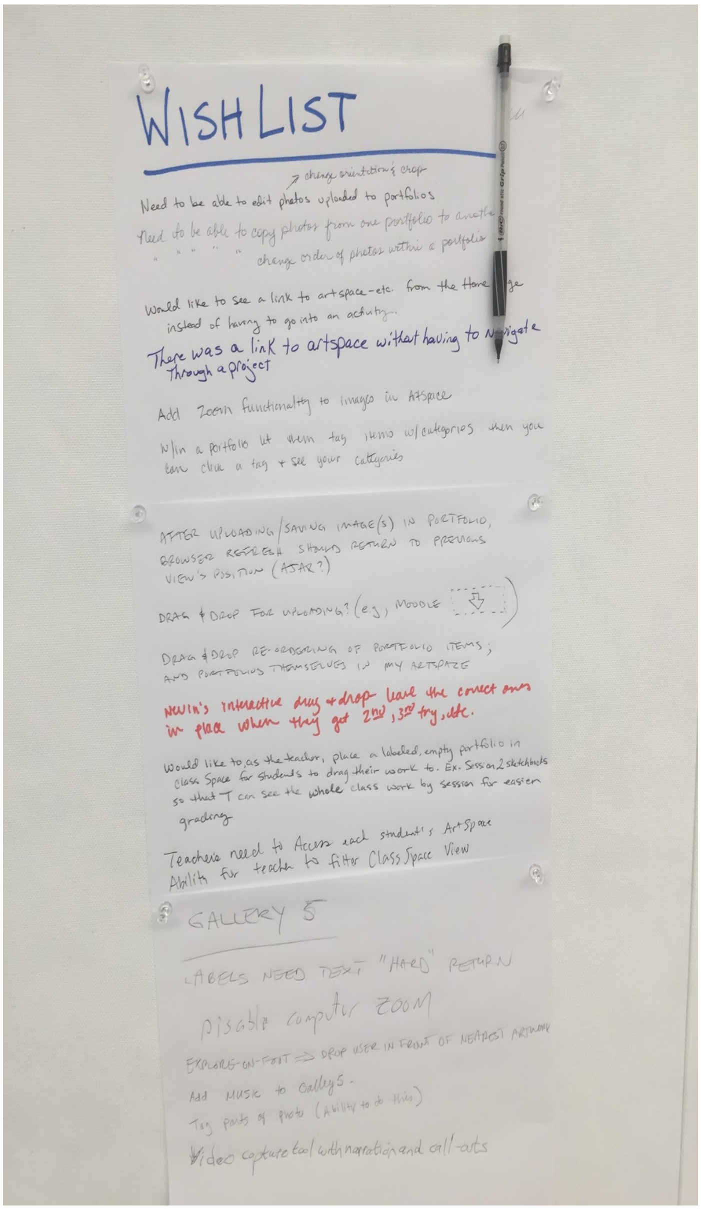

Fig. 9. The teacher future development wishlist.

Overall, the teachers liked the opportunity to tailor their strategies together during the summer training rather than alone at their schools, with one participant saying that “the best part is going in and working and talking as a group.”

6 Scholarly Significance and Discussion

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In the field of learning technologies, part of our purpose is to explore the new and determine its efficacy. However, once the likely effectiveness of a technology tool has support and we want to test it in a naturalistic setting, our role shifts from building and testing the technology to one of professional development and support as the implementation begins. As anyone that works in the field knows, whenever new technology is introduced in schools, there will be challenges. Doing something for the first time can be a daunting proposition, especially with high technical solutions we do not develop personally as teachers. However, professional development is one way that we as educators mitigate the difficulty of doing something new for the first time, both by providing technical training on the devices, as well as pedagogical approaches.

The museum training here both showed where the training succeeded and still has improvements for the next summer, which is what we hope to discover through any evaluation of professional development training and technology use. Our goal is always to do it better next time. The following are some of the recommendations that stemmed from our research for the next iteration of professional development, but are applicable more broadly.

6. 1 Give a great experience: Use exciting collaborative tasks that model what you want teachers to do

A great strength in the training was that the training teachers received mirrored the pedagogical approaches expected by the curricular materials. The teachers had many hands on activities that matched the constructivist paradigm and were engaging and authentic so that they could understand from the student's point of view what they would experience. This helped them understand the technology affordances as well as "pitfalls" in the words of one teacher. In the future, we recommend that more time be devoted to fewer activities, as several teachers hoped for more time to this work because they saw great benefit to know the teaching process and depth of the rich materials the museum provides, but wanted more time with them since during the school year that is something they would lack. The training providers were responsive to this during the five days and that time grew each day.

6.2 Provide administrative task training online and allow pre-work before the training

One area for improvement in the future was allowing teachers to get administrative tasks out of the way ahead of time. The first day, much time was spent creating multiple logins and troubleshooting technical problems, some of which required a solution back on the teacher's home campus with their own technology support personnel. To improve the efficiency of the training, we recommend that any administrative tasks that can be automated for the teachers such as having a single signon be included or that the teachers be allowed to do these ahead to provide more time for instruction, collaboration and support. Further, have the teachers bring at least one of the devices that their students will likely be using so that the development team can test them to ensure their compatibility and to know what workarounds to develop before the product is integrated during the implementation following training.

6.3 Ensure the professional development classroom is ready for technology

A simple way to ensure a positive teacher experience is to do an analysis of what you want them to be able to do and determine whether your classroom will support it. If it is not ready, identify missing resources such as adequate wireless and power for your teachers. If

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possible, spend a day with a local teacher or two walking through the training with them to have them help you identify needed resources you may have missed in the rush to get everything ready to go. We are human and it is not possible to be aware of everything, especially if you are traveling to provide the professional development.

6.4 Be sure your products match the technology the teachers will use

A major issue that about two-thirds of the teachers had was that they did not have technology in their school districts that could support one of the three main tools in the curriculum, the *Gallery 5* simulated immersive experience. These teachers, for whom the curriculum was developed, were in rural districts with limited bandwidth and often have inexpensive Chromebooks that only have Chrome web browsers when the product requires Firefox and the Unity web player plugin. While the professional development itself could not overcome this, taking the time to analyze one's audience at the onset of instructional design to understand their technical limitations in full could limit challenges later and ensure that they can fully use all aspects of the product.

In the future, we recommend spending additional time visiting the classrooms where the product is expected to be used to more fully understand the limits on technology that can restrict a curriculum's use, This, in turn, can ensure that the training they receive meets their needs or provides workarounds for when a technology may simply not work for them, regardless of their restrictions. Understanding the continuum of technology access in a world that still has many strong digital divides, even in the U.S. can contribute to improved training and acceptance of new technologies in the classroom.

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360-degree interactive video application for Cultural Heritage Education

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Abstract. There is a growing interest nowadays of using immersive technologies to promote Cultural Heritage (CH), engage and educate visitors, tourists and citizens. Such examples refer mainly to the use of Virtual Reality (VR) technology or focus on the enhancement of the real world by superimposing digital artefacts, so called Augmented Reality (AR) applications. A new medium that has been introduced lately as an innovative form of experiencing immersion is the 360-degree video, imposing further research challenges. This paper presents a study on the creation of an immersive application that is based on 360-degree video and targets the users' education in the importance of CH. The user is engaged in a journey where they learn about preserved artefacts in the city of Rethymno, Greece and their historical value in a playful way. The integrated architecture and development steps for creating such applications that are based on 360-degree video are demonstrated. The overall design process is driven by the goal to increase the level of immersion offered by incorporating game elements in a realistic storytelling experience. The final application can be experienced with the use of a VR low-cost device such as the Google cardboard and a compatible mobile phone. The study concludes with a set of recommendations and future directions for offering more immersive experiences in the CH sector.

Keywords: user-centered design, 360-degree video, immersion, games, cultural heritage, education, virtual reality

1 Introduction

The desire for better immersion and presence in computer simulated environments has driven an aggressive growth of immersive technologies, presenting new forms of Virtual Reality (VR) media and innovative VR devices. A promising technology for experiencing VR is 360-degree video. 360-degree video offers enhanced realism that although it is possible to produce using computer generated virtual environments, it is resource intensive and expensive process. This enhanced realism offered by video resources when combined with game techniques has great potentials of leading to highly immersive, interactive and engaging forms of experiencing VR. 360-degree video applications are based on free viewpoint videos and resemble navigation in

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virtual worlds of 3D computer graphics by allowing viewers to interactively change their viewpoint in the scene [10] while in traditional video productions the viewpoint is chosen by the director.

In this paper we present the concept and design framework for creating a new form of engaging and immersive applications for CH education that are based on 360-degree gamified video. The overall framework has been designed in order to address a set of technical and design challenges that affect the user experience when experiencing 360-degree video aiming to offer more interactive and engaging educational experiences. The framework is presented through its adaptation for creating an experimental case study for designing an immersive educational application to educate its users in the preserved artefacts of the Historical Centre of Rethymno in Crete, Greece. The study concludes with a set of future steps and possible directions.

2 Immersive applications for Cultural Heritage

There is an increase of interest the last years and huge effort on the research work based on the VR innovative techniques and holographic display devices, the AR applications and the serious games use in the fields of medicine, entertainment, education and cultural heritage. Our study introduces new practices in the development and use of VR technology for cultural heritage education. As presented 15 years ago on Archeoguide [12], AR has been effectively used as a new form for guiding visitors in outdoor archaeological sites with the use of holographic mobile wearable devices (HMDs) and the use of Geographical Information Systems (GIS) data during the creation of the virtual content and the design of the tour. Nowadays, the method of creating such applications has been simplified and improved with the increase on the availability of open source augmented reality Software Development Kits (SDKs), the release of new engines for 3D applications development, the improvement on the results in 3D content creation and reconstruction, the use of "smarter" mobile devices and more effective devices for scanning and tracking.

Augmented reality techniques have been also adapted for creating educational storytelling experiences towards enhancing museums and exhibitions visits and cultural education in schools. AR refers to the tracking of text, images but also small objects that allow the triggering and presentation of adequate 3D models along with 3D text and voice-over explanations creating an enhanced interactive experience. An AR application accompanied by a printed map of Crete, enhanced with aerial photos of the most attractive ancient monuments has been created (Fig. 1) in order to inform its users about the history of the island through a 3D non-linear digital storytelling experience [1]. The user uses an android mobile device and hovers over the images of the monuments on the map. When an image is recognized, the relative 3D model of the monument can be observed along with its 3D text label. The user can through the UI buttons select to listen to historical information of the specific monument in its preferred language (Greek or English) learning about their story of preservation and their role in the past.

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Fig. 1. Android Augmented Reality application for the monuments of Crete

Besides the successful use case scenarios of augmented reality and serious games in the CH sector, 360-degree videos can have a huge potential of generating highly immersive video environments that surround the user and offer an increased sense of presence. In contrast to AR or web-based serious gaming applications, with 360-degree video the users are immersed in the captured real world scene experiencing the feeling of being present in an archeological site and interacting with it though a VR headset.

To support the creation of a rich mental model through 360-degree gamified experiences, a cognitively demanding environment that triggers the user's thinking and understanding of what's going on in the scene should be designed. This can be achieved by devising interesting 360-degree branching narratives that attract user's attention and make the game world believable. Branching narrative belongs to the category of non-linear gameplay where players are presented with challenges that can be addressed through a number of different sequences. In branching, interactive narratives the player can select to follow different subplots of the game story which can lead to its success or failure at addressing a challenge [9].

Applications ,therefore, that are based in branching narratives created with the use of 360-degree video content that depicts archaeological sites and historical places can lead to a new form of immersive educational experiences for the CH sector. Those applications designed by incorporating game techniques can offer a more interactive, engaging and effective way of educating people in the preserved historical monuments of a city and the importance of CH.

3 Integration design framework for 360-degree video applications

There are several challenges and implications that have to be addressed when trying to create immersive, interactive and engaging experiences with the use of 360-degree videos. These challenges are mainly based on the limitations inflicted by the video itself which is used as the main game scene and lacks depth of virtual space where the user can navigate. In conventional virtual environments the user can navigate in complex 3D geometries reconstructing real spaces, attempting to simulate reality, or creating imaginative spaces that cannot exist in real life. Our approach in

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addressing those challenges is to focus on designing strong, realistic, rich and cognitively demanding branching narratives with the use of 360-degree video.

In order to address the technical and design challenges for more immersive and engaging experiences offered by consuming 360-degree video, a conceptual gamification framework for virtual reality applications is proposed. The framework is based on the use of game elements in a 360-degree video environment to enhance user interaction with the medium. The presented framework, as depicted in the figure below (Fig. 2), is the basis for creating 360-degree gamified applications.

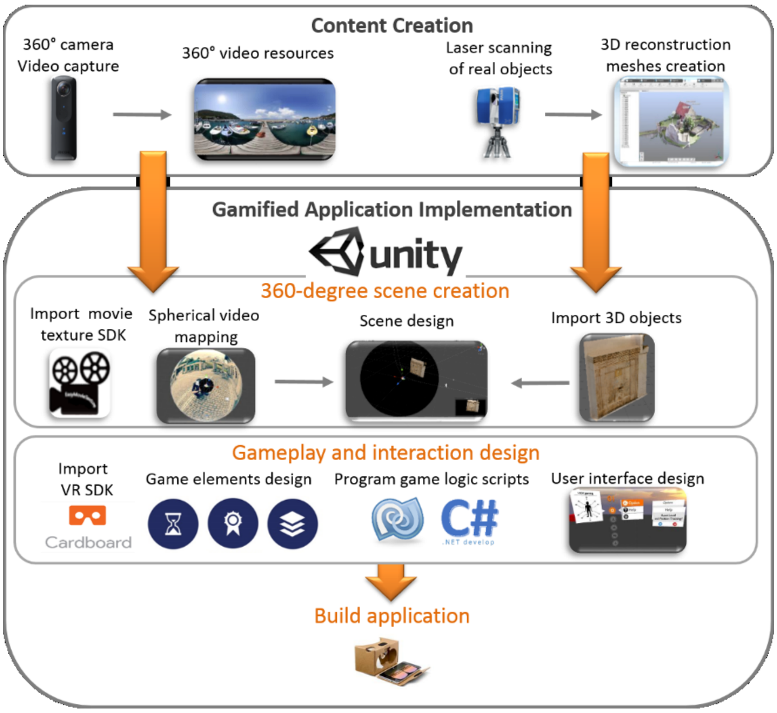

Fig. 2. 360-degree gamification framework.

The main core of the design framework is a game engine and in our case that of Unity 3D [11]. The first step is the creation of the content. 360-degree video resources can be produced using relative production cameras such as the low-cost and easy to use Ricoh Theta S [7]. Moreover, the 3D objects that are necessary for the game design are produced using laser scanning equipment or camera equipment for photogrammetric reconstruction [5] to create the point clouds of real objects and a software tool to convert them to meshes.

The next step for designing 360-degree gamified immersive applications is the creation of the scene (Fig. 3). For creating the 360- degree game scene we follow the spherical approach to define a panoramic environmental surround. A game environment using a spherical approach is created by projecting an equirectangular video onto the surface of a 3D sphere that is inserted in the Unity project's scene and by

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placing the camera at the center of the sphere. The scene design process continues by importing the 3D reconstructed game objects and placing them inside the sphere.

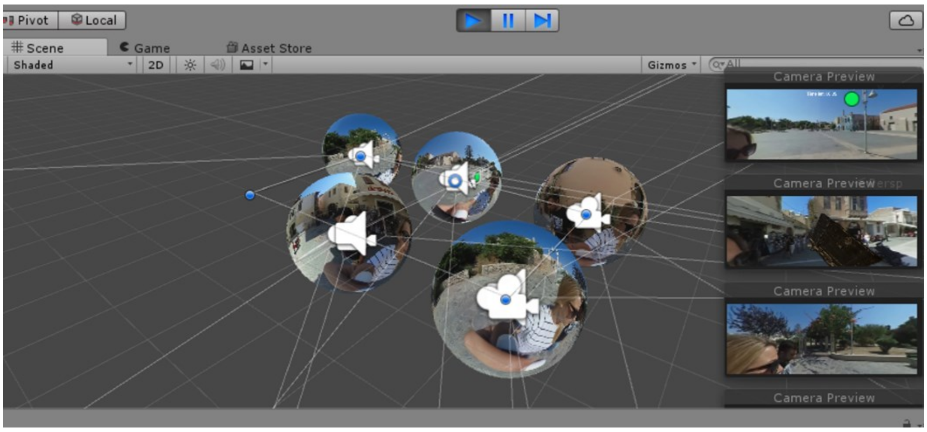

Fig. 3. 360-degree scene creation

To start the implementation of our immersive application, the required SDK for building VR mobile applications targeting a specific device must be integrated (such as Google cardboard VR SDK [4]). Then we move to the design and integration of our preferred game elements, such as time pressure mechanisms, badges assignment techniques and level-systems and the programming of the required game logic scripts to run the game scenarios. The user interface of the gamified application is also designed to support the user interaction with the content and the overall game logic, such as the display of notifications, the level/ points/badges visualizations and the navigation support view. In addition, scripts are used for defining the game logic and designing interaction processes and events.

4 Historic Rethymno Interactive 360-degree application

Our case study is based on the use of the 360-degree gamification framework presented earlier to create an immersive educational application of a treasure hunt game in a cultural heritage site, that of the historical center of Rethymno city, in Greece. Rethymno city has been chosen because of its great historical importance, preserving artefacts and monuments in good condition from different historical periods such us the Ottoman and Venetian periods, useful for designing interesting branching narratives. The game has been developed to be used with the Google Cardboard VR device and an Android mobile phone. In order to create the gameplay, several video resources have been produced capturing the user's movement in 360-degrees view between the several key areas, historical buildings and artefacts on the site to be used for resembling user navigation in the virtual scene. Moreover, a list of short-time 360-degree videos per area of interest where also captured in first person view depicting the user standing in the middle of each area or in front of a building, to allow the ex-

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ploration of the place in 360-degree view. Those exploratory video resources are used to create a mixed media scene where 3D objects depicting important historical artefacts are integrated in order for the user to be able to identify them in the scene and move to another level of the game. Those 3D realistically reconstructed objects represent important historical remains of the Ottoman period that can be found in the old city of Rethymno [3].

The logic of the overall gameful experience is designed based on the concept of exploratory games that allows the user to freely navigate and revisit several stages/levels of the game by experiencing different narratives till he identifies and completes all challenges presented [6]. The exploratory approach triggers the users' curiosity motivating them to master the rules and affordances of the game by supporting them to level-up and advance in the game, making the whole experience more engaging.

The game starts by displaying the first 360-degree video short clip where the player stands at the middle of a square in the historical center of the city. The player has the role of an Ottoman soldier missioned to collect water from several historical fountains of the Ottoman period, which remain in the city, and carry it to the most important fountain of the city, the Rimondi fountain [8], in a specific time limit.

The player is presented through the UI with the first challenge asking to spot three historical fountains that are placed in the main square scene. Challenges are continuously presented to the players at each level of the game that increase their interest while testing their knowledge and allowing them to apply it. Addressing challenges makes people feel they have earned their achievement giving them the sense of accomplishment which is one of the eight core drives of gamification according to the Octalysis gamification framework [2].The scope of the game is to spot these fountains in the scene in order to later on place them at the Rimondi fountain.

After collecting all the three fountains, the player is requested to peak one and select to move towards its real location through the shortest path between two possible options (branches). Thus two possible branching narratives are provided for each selected fountain. Depending on the selected path, players are presented with different historical information and/or clues contributed to the gameplay. The triggered video resource is depicting the player walking in the chosen direction towards the area in the city where the selected fountain is actually placed. Then the next video clip is played with a time limit to address the next challenge which is a historical question about the fountain. The question can be answered by analyzing the information gained during the tour in the selected path.

After having visited all the locations of the fountains in the city the players are transferred to the location of the Rimondi fountain. At this final stage, the collected fountains can be placed on the three tabs of the Rimondi after answering a historical question again for each one of them. When all fountains are placed in Rimondi, the game ends and the players are addressed with a Gold, a Silver or a Bronze badge of the Ottoman citizen of Rethymno according to the points collected though addressing the challenges imposed.

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A snapshot of the gameplay is shown at Fig. 4 depicting the main UI elements, the radar map, and the water level indicator that depicts the points gained, the time limit and the play/pause button.

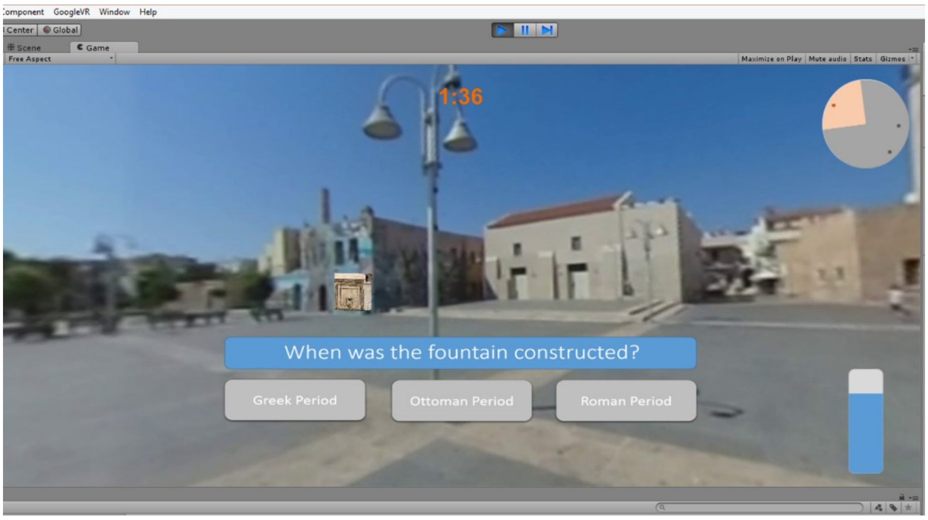

Fig. 4. Gameplay snapshot.

5 Conclusions and future directions

360-degree video is new promising technology for creating virtual reality immersive applications. Educational gamified application that incorporate such technology could offer more engaging experiences and increase the level of user's immersion. The presented case study for the Historical Centre of Rethymno and the proposed design framework is a first approach towards presenting the benefits of the 360-video use in the creation of immersive educational applications.

To offer the user the expected feeling of immersion and sense of actually participating in the game story, an interesting story game that unfolds through 360-degree videos has been designed. The main game story has been based on the branching narrative technique presenting a virtual scenario where the user has the option though interacting with the environment to experience it in different ways. This technique offers the user an enhanced sense of presence as it creates the feeling of controlling and actually taking part in the scenario. Good stories attract the user to the gaming experience while make the world seem more believable. A list of other game mechanics have been integrated in the design of the gaming experience and the UI, such as revealing challenges accompanied by time pressure techniques and the assignment of points, levels and badges that engage the user by giving the sense of accomplishment and progression in the game. Navigation and orientation mechanisms have been also used through the incorporation in the UI design of 360-degree "radar" maps depicting

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the field of user's view in real time and showing the position of points of interest in the scene.

All the above presented and incorporated design techniques to our case study should be evaluated in the future through usability studies involving real users. Real user studies will provide us with the necessary results in evaluating our approach for the effective use of 360-video interactive content in CH education. Future steps include the planning and execution of trials involving representative users from the targeted categories such as professionals in CH sector, undergraduate students in History and Archaeology and citizens of the Rethymno area.

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Evaluating the Lifelog: a Serious Game for Reminiscence

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Abstract. Body worn cameras record lifelogs as a sequence of images and one therapeutic use is to promote reminiscence in older people. We investigate if the emotional response of the viewer can be used to identify images of interest and whether this can become a serious game for shared interaction with a family member or carer. To evaluate whether this is technically feasible we report on a small evaluation of five healthy participants (Male=3, Female=2) aged between 24-46 years of age. Participants reviewed lifelog images six months after the initial data collection. Galvanic skin response readings were recorded and matched to the image stimuli. By monitoring such responses it is possible to organise the lifelog into events, potentially highlighting activities of daily living and social interaction for subsequent reminiscence. Initial results indicate emotional responses can be quantified and detected but no clear classification of emotional trends emerged. We suggest improvements in methodology to make the approach viable and discuss the need for data reduction. As wearable technology improves, the approach can add to the quantified-self paradigm, allowing wider application to learning and training.

Keywords: Reminiscence, Serious Game, Galvanic Skin Response, Personalisation, Pervasive Computing.

1 Introduction

Reminiscence Therapy (RT) involves the “discussion of past activities, events and experiences with another person, usually with the aid of tangible prompts such as photographs” [1]. There is evidence to suggest that it is effective in improving mood in older people. As such, it may be the basis of a ‘serious game’ for older people and carers/family members to support shared interaction and inclusion. As a side effect, it may stimulate memories and hence support cognitive wellbeing, although this process is less well understood. According to Collins dictionary, a lifelog is “the practice of digitally recording all of one's daily activities by for example wearing a camera that takes photographs every few seconds”. The resulting images may be uploaded to a computer for later retrieval, thereby building up a digital record of daily existence

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activities. A lifelog could be used to monitor social interaction and to monitor food intake and other activities of daily living (ADL). Gordon Webb is a pioneer of the silver surfers [2] who have adopted the quantified-self paradigm [3], utilizing body worn cameras (e.g., Microsoft SenseCam) for lifelogging. He stated: *"I have built up about 100 sequences, consisting of 60,000 to 80,000 images. That content varies from pleasant walks to conferences, so I can see who I was talking to. The camera marks the time that all the pictures were taken, and then I upload the images into a single folder, labelling the sequence so that I can retrieve it later."* [4].

In addition to this extension of the pervasive computing paradigm, human computer interaction continues to evolve by enriching the computer with artificial intelligence attributes. Affective computing couples the user with the technology in a close symbiotic relationship; it relates to or arises from human emotions and encompasses computer science, psychology and cognitive science [5]. The use of physiological recordings (e.g., heart rate, respiratory rate) is a critical input for quantifying affective computing. Speech metrics, facial and gesture recognition can be used to interpret a user's emotions in this paradigm.

1.1 Galvanic Skin Response

The Galvanic Skin Response (GSR) measures the electrical conductance of the skin; it can vary depending on the amount of moisture, specifically sweat, on the skin. As the production of sweat is controlled by the sympathetic nervous system [6][7], the measurement of GSR has been used to indicate psychological or physiological arousal [8][9]. If the sympathetic nervous system is highly aroused, then the body activates sweat glands, which in turn increases skin conductance.

A GSR sensor measures the electrical conductance between two points on the body, typically at the extremities (fingers and palms), usually positioned about an inch apart and measured by injecting a harmless small current. Conductance varies depending on the emotional state of the subject. The most common use of GSR to measure arousal is as a component of a polygraph test (lie detector) [10], in conjunction with other parameters such as heart rate and respiration rate. Biofeedback therapy also uses GSR to measure and display a subject's stress levels with the view to help them identify and control anxiety [11].

The environment in which the GSR data collection occurs can have an impact on the consistency of results. Factors such as temperature and humidity naturally affect the skin conductance of the subject [12][13]. In addition to this, GSR responses are typically delayed between 1-3 seconds after the presented stimuli [13] so temporal adjustment is needed to match responses to stimuli.

1.2 Serious Games and Reminiscence

A serious game has a primary purpose other than entertainment, in this case to promote social interaction and wellbeing. Review of lifelogs with a family member can be considered as a serious game, providing context for shared interaction. McCallum and Boletsis have provided a taxonomy of serious games for dementia

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[14]. The taxonomy categorises games as {cognitive, physical, social-emotional}, game types as {preventative, rehabilitative, educative, assessing} and player types as {potential patient, patient, public, professional}. Cognitive games trigger the cognitive abilities of the player; social-emotional games encourage players to link with their friends, providing shared experiences and discussion opportunities. Rehabilitative games have therapeutic functionality; assessing games to provide data to the player about his/her health status. Hence the work described in this paper may be categorised as: game category {cognitive, social-emotional}, game type {assessing} and player type {professional}. Of course, our intention is to investigate potential patients in the future, with a view to provide rehabilitation of cognitive function.

However, the jury is still out on the efficacy of such games for older people. A review by McCallum and Boletsis [15] concludes that: *"many games developed for entertainment purposes are used for health reasons, acquiring the characteristics of serious games….. dementia games do have an effect on cognitive impaired people. If that effect is longlasting and/or transferable to the daily activities is a matter of further scientific investigation."*

Our hypothesis is that context such as location, people involved and changes in environment within the lifelog will have an effect on the viewer's arousal. The goal of this evaluation is to determine if GSR signals can be used to identify 'images of interest' during reminiscence of lifelog data. The rationale is that arousal can potentially be used to personalise the organisation of the collected data. This could result in streamlined lifelogs with more meaningful events that stimulate the user and hence promote shared interaction with a carer. By providing further context for the interaction, such as assessing for an event of interest: {what happened?, who is involved?, where did it take place?, when did it take place?, why did that happen?}, we can build this reminiscence interaction into a serious game.

2 Methods

Participants were asked to use software to review previously recorded lifelog data. A reminiscence software package was developed to support this. They used a wearable sensor around their wrist that connected, via two small wires/electrodes to two of their fingers, to collect GSR data. Following a brief calibration phase, participants were shown a series of images, in order to achieve a baseline measure. Participants navigated a previously recorded lifelog at their own pace while GSR data were subsequently recorded. The data collected were (i) GSR data sampled at 10.6 Hz (Comma Separated Variable, CSV format), (ii) Screen recording of both GSR waveforms and Reminiscence package screens, i.e. the evoking images.

The data were collected using a Shimmer sensor [16] with an additional GSR board with two electrodes attached to the index and middle fingers of the user's left hand. In order to collect the GSR data from the sensor, the Shimmer Connect software [17] application was used to stream data from the sensor to the recording computer.

Participants were recruited to test the hypothesis that 1) reminiscing of lifelog data has a physiological effect on the reviewer and 2) that this change in physiological

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arousal can be used to personalise lifelog and hence reminiscence. Five participants from a previous evaluation of a wearable lifelog system [18][19] were recruited to review their lifelog data whilst wearing a GSR sensor, see Table 3 for user demographics. The Faculty of Computing and Engineering Research Ethics Filter Committee at Ulster University granted ethical approval for this research (study number: 2014.030614.22).

As all of the participants were healthy volunteers (without cognitive decline); the aim was to test efficacy of the methodology. The recording took place six months following the collection of the initial lifelog data in order to minimise the possibility of simple memory recall and hence simulate reminiscence. Participants were asked to sit quietly while eight standard images were presented (as slides using Microsoft PowerPoint) to establish a personalised baseline, as GSR responses are highly individual and direct comparisons between subjects can be misleading [20]. Each slide was shown for 5 seconds and contained images of varied valence. The images aimed to promote both positive (kitten & puppies) and negative (snake & spiders) emotional responses. In addition, two of the eight slides contained coloured words that invoke the Stroop Effect [21]. The Stroop effect is known to evoke stress levels by affecting an identification task (e.g., the word “Red” written in “Blue”; identify colour or meaning). The baseline allowed for settling of the GSR personalised to each individual, for the ambient experimental conditions.

Participants were then presented with the lifelog images they had recorded using the miLifeCam sensor component [18]. Approximately 300 images had been recorded for each participant. These images were played in sequence at a rate of one image every two seconds. During this time, participants sat in a silent room with the researcher passively viewing the lifelog; they did not actively interact with the technology or researcher. Participants were asked to remain silent throughout the evaluation. The researcher recorded the GSR data as a CSV file for later analysis. In addition to the capture of the GSR data, stimulus and waveform screens were recorded, so that GSR readings could be matched with stimuli. The GSR data were subsequently manually aligned with the screen recording of the lifelog review to identify associations between the images displayed and the participant’s emotional arousal.

The researcher reviewed the screen recordings and the data were segmented into six categories (Table 1). The GSR data were visualised into charts and annotated with the categories of lifelog images, factoring in the delay in GSR response [13]. When interesting GSR events, such as sharp peaks and troughs, were visually identified, the corresponding visual stimulus was retrieved and added to the annotated GSR charts. A deviation of more than 5% of the range of the data over 5 successive time samples was used to determine this. In Section 3 an annotated GSR chart and summary explanation is presented for one of the five participants along with a meta-analysis of the remaining four.

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3 Results

GSR responses together with an overlay of the visual stimuli were developed for each participant. From the collected lifelog data from all participants, four event types were identified along with two non-specific event types, presented in Table 1. This allows the identification of the type of activities that were viewed during the reminiscence period that produce potentially interesting peaks and troughs in the GSR data, i.e. changes in skin conductance.

Table 1. Event types used to segment the GSR data during the reminiscence period, with typical activities that occurred during these events.

Event Type	Typical Activities Within This Event	Total number if GSR events Identified
PowerPoint Viewing (baseline event)	Viewing the images described above.	1
Bathroom (ethical consideration)	Camera deliberately obstructed or removed for the participant to use the bathroom. Typically displayed black/dark images.	0
Stationary	Sitting at their desk. Not moving between environments with no significant interactions.	14
Travel	Moving between rooms. Walking along corridors and walking up/down stairs. Sometimes results in blurry images.	4
Social Interaction	A social interaction with a colleague, or researcher. Clear visual identification of another person in close proximity.	7
Eating	In the process of eating food, either alone or with another person. Clear image of food being consumed.	0

3.1 Sample Participant (P5)

P5 was a 46 year-old male with a *miLifeCam* dataset of 319 images. From the GSR dataset collected, seven GSR events were identified, see Figure 1. The first event was captured when the participant was looking at the PowerPoint presentation. This is the only participant of this evaluation who showed any significant response during the PowerPoint phase. Nevertheless, as this evaluation was investigating the effect of lifelog data on physiological signs, this event is not deemed important from a reminiscence perspective, yet it illustrates the possibility of GSR for quantification. The second event occurred just after a colleague joined the participant for lunch, see Figure 2. The interaction that seems to trigger the response is the image of the new person/interaction sitting down at the table.

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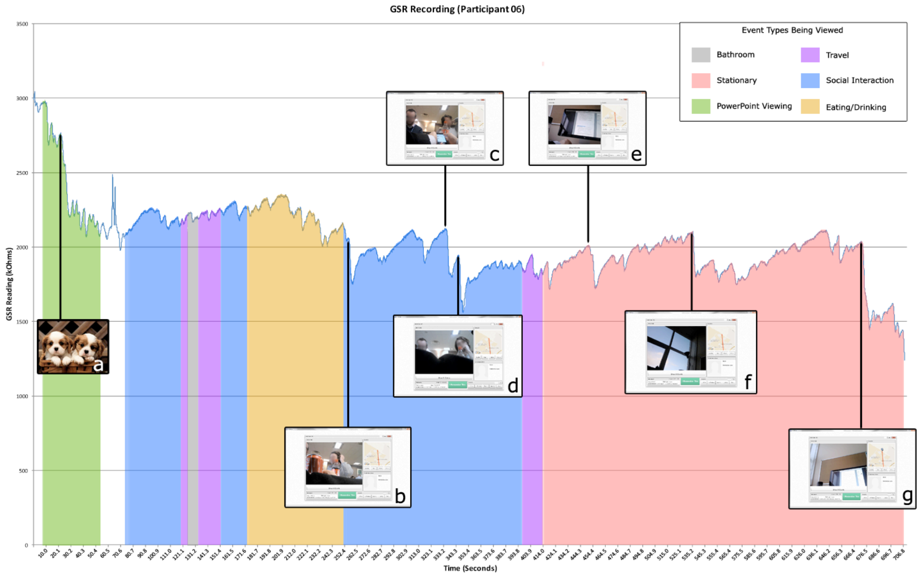

Fig. 1. P5's GSR data (conductance specified in kOhms versus time epoch) recorded using the Shimmer sensor during the reminiscence phase. Troughs in the data were identified and the corresponding image the participant was viewing at the time is overlaid upon the GSR.

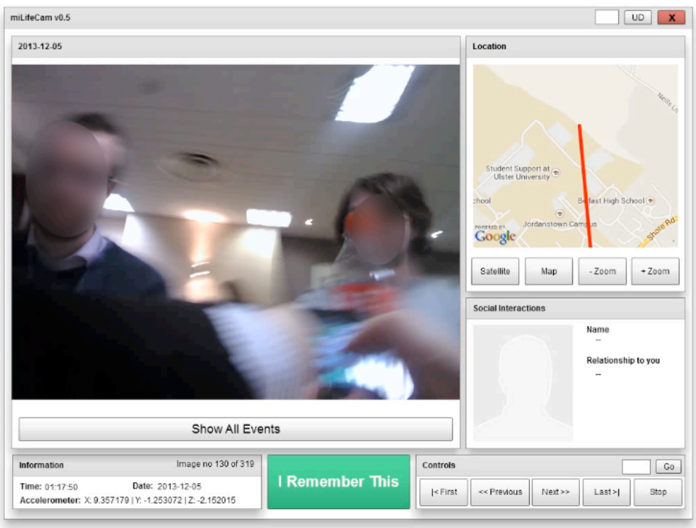

Fig. 2. Screenshot of the Reminiscence Tool interface, presenting a sample social interaction image presented to P5 during reminiscence GSR event detailed in Figure 1.

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On some of the images, P5 was looking at the food he was consuming. During the social interaction, it may be deduced that P5 was using his smartphone and it is reasonable to assume that this may have been the catalyst for the new GSR event. The fourth event occurs during a series of images clearly showing the two social interactions the participant was having. No other pieces of technology or persons were in the series of images. The next identified event was when the participant had returned to their office and began to work on an academic paper. After a series of images of the document on the screen, P5 reviews a paper copy of a document. At this time P5 lays back in his chair offering a view out of their office window. This triggers the sixth event. The seventh GSR event identified occurs as P5, again lying back in the chair, views the monitor with a document displayed.

Figure 3 summarises the GSR data of all five participants in this study. P3 and P5 have similar levels of GSR, as do P2 and P4. It should be noted that during P1's evaluation phase, the temperature in the room during recording was 28 degrees Celsius, which resulted in much higher skin conductance levels by comparison with the other four participants.

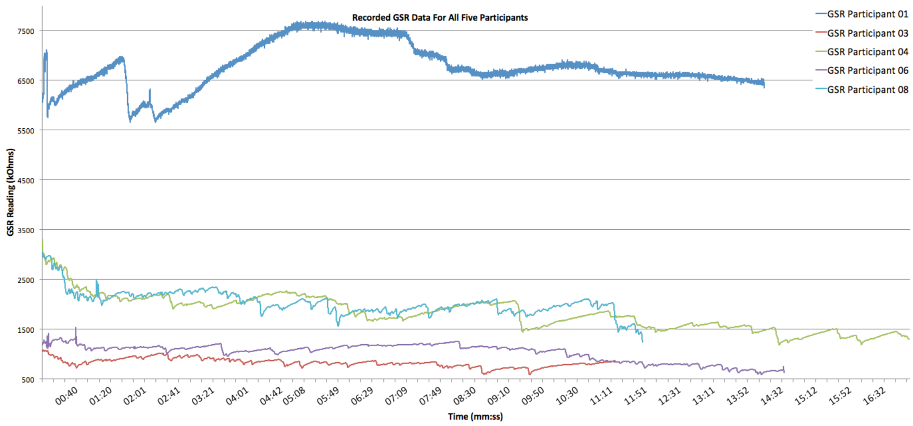

Fig. 3. Variability of GSR over time during reminiscence.

3.2 All Participants

Following the analysis of the collected GSR data of all the participants and the visual identification of GSR changes, Table 2 was compiled to categorise the event types and occurrences. Of all the interesting events identified from the GSR data, the event type that had the most GSR events identified was paradoxically "Stationary" with 14 events identified. "Social Interaction" event types were the second most common event type to generate a GSR response with seven occurrences. "Travel" initiated four GSR responses. Somewhat counter-intuitively, eating was not reflected in GSR events.

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Table 2. Participant demographics and associated events evoked from lifelog images (P1 - 5).

Participant Demographics	Life Log images	Events	Comments
P1 (Female, 45)	327	E1.1 Baseline (Stroop) E1.2 Stationary E1.3 Social Interaction	Due to high temperature, the GSR looked to be saturated (see Figure 3 GSR P1)
P2 (Male, 34)	310	E2.1 Stationary E2.2 Social Interaction E2.3 – 2.6 Stationary E2.7 – 2.8 Travel	P2 had the most peaks and troughs in their GSR data. Nevertheless, these GSR features were not as defined as those of P5
P3 (Female, 24)	325	E3.1 – 3.4 Stationary	Despite all of the GSR events occurring during a Stationary event type, the lifelog data shows that P3 carried out five of the six event types in Table 2
P4 (Male, (32)	335	E4.1 Travel E4.2 – 4.3 Social Interaction E4.4 Travel	Both travel and stationary event identified
P5 (Male, 46)	319	E5.1 Baseline (Puppies) E5.2 – 5.4 Social Interaction E5.5 – 5.8 Stationary	More detail can be inspected in Fig 1, with evoking stimuli in Fig 2

4 Discussion and Recommendations

This experimental approach attempts to correlate visual stimuli with subjectively assessed GSR arousal. If we can measure relevant events with GSR then it be a means of prompting the *recording* of the lifelog itself. The rationale for this is the need to reduce the overall lifelog data set for pragmatic deployment. Lifelogs generate so much data of a similar nature that they become less useful, suffering from the 'big data' anomaly. Contextual information can potentially facilitate a reduction in data collection and storage.

The images used in the PowerPoint presentation (baseline) were chosen in order to evoke positive and negative emotions. The use of IAPS (International Affective Picture System) [23] could have been used as it provides images that have a standardised emotion evoking score [24] . GSR may change according to both exogenous (external) and endogenous (internal) events. Certain aspects of the collected lifelog data trigger some form of emotional arousal as identified by the GSR recording. Nevertheless, they may not be consistent enough for us to conclude that changes in environment, as captured visually, prompt an emotional response. While there may be a relationship between the images viewed by the participants and their GSR arousal, addi-

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tional modes of stimulation could produce a more representative arousal level. If additional information, such as a sound captured, was played back during reminiscence, it may have a more consistent effect on the participant's arousal levels. Other relevant sensory stimuli are not capable of being captured, as part of the lifelog (e.g. the 'smell' of an environment that may prompt an emotional response, a technique well known to supermarkets). Research is being conducted into the transmission of smells using technology systems [22].

The detection of specific events within GSR data is challenging due to the sensor measurement being ambiguous and dependent on hidden contexts such as physical activity and room and body temperature [26]. Additional physiological metrics could be included in order to obtain a more robust measure of emotional stimulation in reminiscence. Using GSR alone as a metric for assessing emotional response when reviewing large datasets appears promising but may not be specific. Metrics such as heart rate, body temperature and respiration rate would also result in more quantitative and robust results. Nevertheless, intrusiveness would be increased.

It is also unclear if the responses are as a direct result of the stimuli presented to the participants, as opposed to environmental factors (sound, temperature and physical comfort during the review process etc.) or even boredom. To address this issue the addition of eye-tracking technology would help us to establish task engagement. By combining the GSR data with eye tracking it may be possible to establish what aspects of a particular image may have influenced the physiological change. A less sophisticated alternative to eye tracking, would be asking participants to talk 'out loud' about what they felt when reviewing the images. For example, if they remembered anything about the people or environments that were shown.

The identification of a GSR 'event' should also be empirically verified in an automated way. The use of a derivative and threshold approach would allow the automated detection of specific change points. Another approach is the use of CUSUM (Cumulative Sum) as a means to detect changes in the recorded physiological data [25]. A more rigorous approach would harness data analytic algorithms for the identification of significant events. Advances in wearable technologies mean that the collection of physiological data, such as GSR, heart rate and body temperature are becoming more ubiquitous (and less costly). Nevertheless, these commercially available devices are typically tied to their own software ecosystem and do not allow third party developers access to the raw data in order to classify specific emotions. If the raw data were available, the scope of emotional response recognition has many applications outside the realm of healthcare technologies.

One limitation of this investigation is that all the participants were younger, <=46 years of age, and as such would typically have better memory recall than older participant for whom reminiscence is designed. A further evaluation should be undertaken with older participants and their lifelog data, as age and medication consumption have been shown to have an effect on the GSR results [12]. The use of IAPS images would establish a verified baseline. This study was carried out with only images and no additional stimuli such as sound. The introduction of sounds would have some effect on the participant's arousal level. The use of sounds in addition to visual stimuli would be suited to serious gaming.

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4.1 A serious game for reminiscence

In this work we have evaluated the use of GSR with healthy volunteers. With a lifelog dataset, collected by a person with Dementia (PwD), a serious game can be developed to match the taxonomy of [14], specifically the *Cognitive*/*Social-emotional* serious games category, thus providing an *Assessing* serious game, possible a *Rehabilitative* game. By modifying the Reminiscence Tool used to review the life-logged data, (Who, What, When, Where, Why) questions based on the collected images could be asked, Fig 4. For example: Who is this, What are they/you doing, When and Where was this and Why were you here/doing that? Using the GSR recording hardware, the user's emotional response and thus agitation could be monitored resulting in onscreen hints and prompts. Coupled with eye-tracking, the user's engagement could be monitored and multimedia prompts could be provided. Metrics such as the number of correct and incorrect answers, the duration of task completions, total engagement and physiological responses could be used by professionals and carers to provide an assessment over time.

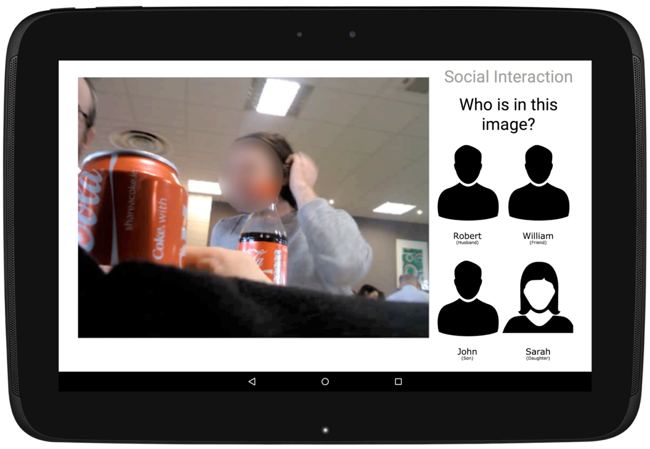

Fig. 4. Serious game for assessment of reminiscence (proposed).

4.2 More general applications

In the longer term it is indeed possible that the emotional response, and thus attention, of students could be monitored in real time by educators that could i) specifically target a student who is falling behind in a class or, ii) modify their teaching techniques to accommodate students preferred learning methods. By responding to changes in emotional response while looking at visual stimuli further possibilities for use in serious gaming can be identified. Difficulty, duration and intensity can be adjusted to match the user's affective state. One example would be how a pilot would respond emotionally to various scenarios during a flight simulation. In addition to testing the emotional levels of a user in a serious game, mindfulness could be explored in real-time. During a stressful simulation, an affective serious game could not only monitor the stress levels of the user, but assess how they overcome the increased stress levels

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to solve the problem posed. The proposed methodology can also be applied to the design of the architecture of virtual environments. By placing the user in a virtual environment, for example a newly proposed museum, the layout of the building in addition to the placement of exhibits could be evaluated for changes in emotion. The placement of artwork in a dimly lit room would potentially evoke a different response than if the same artwork were placed in a well-lit and cluttered area. The physical layout of the building could also be evaluated for 'pain points' in navigating to various exhibits.

5 Conclusion

This paper presented a feasibility study into the use of GSR to ascertain if there is a physiological response from participants reviewing lifelog data, collected six months previously. We addressed whether such physiological data could be used to personalise the lifelog. Results show that the reminiscence of lifelog images affects four of the five participants evaluated. Incidentally approximately 10% of participants in GSR studies are non-responders (hypo-responsive) with regards to their electro dermal activity [13]. The small sample size and data variability mean that no specific event type can be identified, nor was any specific emotion identified. Additional stimuli during the life-log recording, such as sound, could trigger more GSR responses than reminiscing with images alone. With the computation power of smartphone technologies, and the wearable nature of the GSR sensor, it would be possible to modify the *miLifeCam* sensor component to integrate the GSR sensor input to trigger the capture of images as and when the user's arousal levels change above a certain threshold (or indeed based upon some other criterion). This *affective miLifeCam* component would in turn reduce the number of images captured and mean that the data presented during reminiscence could be more emotionally relevant to users. As wearable technology improves, the approach can add to the quantified-self paradigm, allowing wider application to learning and training.

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Drinking Games: Simulating Alcoholic Behavior Patterns in the "Pubcrawler" Video Game

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Abstract. Pubcrawler is an interactive video game that presents concepts of alcoholic behavior within actionable gameplay. By implementing simulations of impairment in gameplay controls and player tasks based on denial, rationalization and concealments behaviors, this game is intended to use traditional gameplay elements to immerse the non-alcoholic user in the alcoholic's experience and promote understanding and empathy, and also elicit reflection in the alcoholic user to aid therapy.

Keywords: Serious Games, Educational Games, Empathy Games, Alcoholic, Immersion, Virtual Environment

1 Introduction

Although they have their origins as entertainment, video games are no longer restricted to that domain. Games have, in recent times, found applications in a wide variety of fields such as healthcare [2], the military [19], education [21], marketing [14], cultural experiences [17] and art [20]. Video games are a novel, rich media platform with a multitude of moving parts in regard to inputs. The inputs interact with a range of virtual and real environments, including mixed reality combinations. The results are either experienced by the user via a rich media display and/or by the real and virtual consequences of play and experience. These are increasingly being used for new means of expression and communication.

The continued use of games depends on the motivation to play, and part of this is the immersion and engagement for the user which is achieved when there is well-designed interaction with virtual environments. Additionally, the ability to interact with elements in a virtual world is a characteristic unique to video games. This opens up novel ways to approach applications that have previously relied on verbal communication, written text and/or film. With the increasing thirst for virtual worlds comes a realization that real-life situations can be reflected back to the user through the adjustable prism of the full range of virtual environment manipulation options. The understanding one gains from reading descriptions of an experience or having this experience verbally explained is a different and more impersonal understanding than that gained from experiencing, to some extent, something itself [13].

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As an educational platform, games offer a unique interactive environment whereby you can present concepts that the user can actively interact with and experience. By directly acting out these behaviors as a result of the playing the game, the player experiences deeper learning and empathy. The rise of 'indie gaming' due to the internet and games distribution systems such as Steam has spurred innovation in the gaming scene with smaller games makers being more able to take risks on games that may not seem commercially viable. The availability of professional and highly adjustable games engines (e.g. Unity3D and Unreal) that are free-to-use up to a certain distribution level have also ignited a diversity of themes and topics represented in games by developers. For example, a new wave of 'empathy games', games which aim to let the player experience situations from the perspective of a certain group of people with the intent of fostering empathy, have started to emerge in the games market.

One such game called "Depression Quest" (Fig.1) is an interactive game dealing with the subject of depression independently released in 2013. The game was available initially as a web browser game, then from the digital publishing platform Steam on a free/pay-what-you-want basis. It is largely seen as educational, and has links to the United States National Suicide Prevention Hotline. As an example, it is probably far away from a traditional game developed for entertainment as has been seen yet, and epitomizes some of the furthest ranges that independent game development has pushed the definitions and subjects of modern video gaming. Reaction to the game can be seen in online forums, and an unofficial sample of the reaction shows that a slim majority view it as a positive experience [1]. Reactions from sufferers make note of the recognition of symptoms and reflections of their own condition, including the feeling of not being alone and also of having therapy options. Reactions of non-sufferers indicate some understanding of the condition being developed after the game.

Some studies have illustrated the potential of video games as a tool for fostering empathy [3],[11]. Games have the potential to allow for greater understanding of different perspectives because the medium allows for experiential learning; unlike other forms of media such as film or television wherein the user is limited to an observer of performing characters, games allow the user to assume the role of the game character themselves [8]. Careful consideration must be given to the design of an empathy game. Studies suggest that players are more likely to default to playing "unempathetically" unless prompted to do otherwise [4]. Belman and Flanagan outline four design principles that can serve as a guide (it is noted that good examples of empathy games very rarely exemplify all of the following) for the development of games for fostering empathy [5].

1. Encourage the player to actively attempt to empathize at the start of the game
2. Allow the player to engage in 'helping behavior' to address issues in the game
3. Appealing to emotional empathy is only effective if it doesn't require a significant paradigm shift from the player
4. Give the player a means of identifying with game characters by emphasizing similar human experiences

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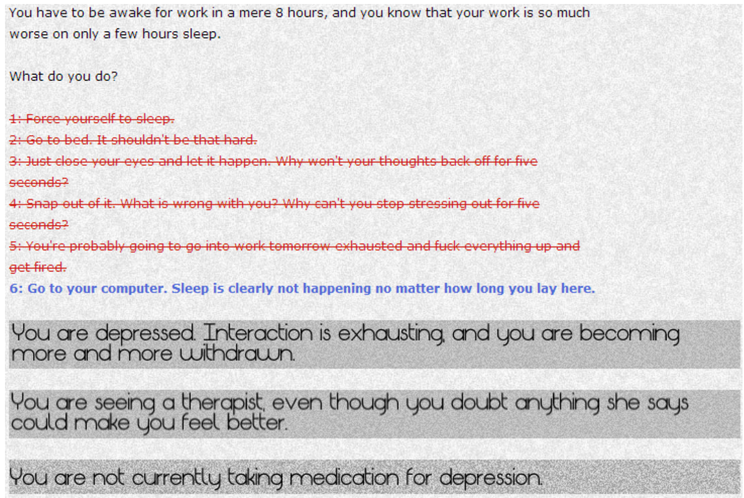

Fig. 1. Screenshot of the gameplay of Depression Quest (Source: `http://loser-city.com/features/on-depression-quest`)

Note that the first principle does not necessarily require that the designer explicitly instruct the player; a more subtle approach can be taken. For example, directly addressing the player as if they are the player character can serve as a gentle suggestion that the player is meant to be putting themselves in the perspective of the player character. It is also suggested that resemblance between the player's method of interacting with the game and the resulting action of the controlled game character may have a significant contribution to achieving strong parallel empathy (i.e. players mirroring the emotional state of the game character) [5].

In this paper, we present "Pubcrawler", a simulation of impairment and alcoholic behavior with the intent of increasing awareness of potentially unhealthy thought patterns and behaviors surrounding alcohol. Concerns about the British 'binge-drinking' culture feature fairly frequently in the UK media, and while definitions of what constitutes 'binge-drinking' may vary [16], studies confirm that many young adults of university-age are consuming alcohol in amounts above the recommended limit [22], [10], and, on average, young adults in the UK drink more than their European counterparts [12]. Pubcrawler aims to challenge the normalization of unhealthy drinking habits and to reach out to those experiencing the behavior it emulates to provide recognition as a therapeutic step. While Pubcrawler utilizes traditional gameplay elements, it belongs to a more recent wave of games dealing with more realistic situation and which have the potential to educate, induce empathy and understanding.

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2 Game Design and Rationale for "Pubcrawler"

Pubcrawler is a desktop game designed as part of the requirements for the Games Interaction Technology module at the University of Westminster, using the Unity3D engine (Fig.2). The game uses a 3d top-down view where the player can navigate the streets in order to accomplish tasks, with some interruptions/mini-games/further missions arriving via the player's in-game smartphone. The overall concept is a top-down stealth game following Clive, a closet alcoholic, as he attempts to return home from the pub while hiding his alcoholism from his roommate who is becoming increasingly concerned about Clive's drinking habits. The main aims of Pubcrawler are to show the player the perspective of an alcohol, including feeling a lack of control, frustration, the compulsion to drink, shame, denial and avoidance with the intention of making the player familiar with some signs that might indicate an unhealthy relationship with alcohol. These aims are communicated in multiple methods, including the main gameplay themes, gameplay mini-tasks, motivation, interaction, navigation, collectibles, and control systems. With all elements of video games serving the theme, it is felt that there will be a strong communication of the concepts and issues at a deeper level than traditional outreach.

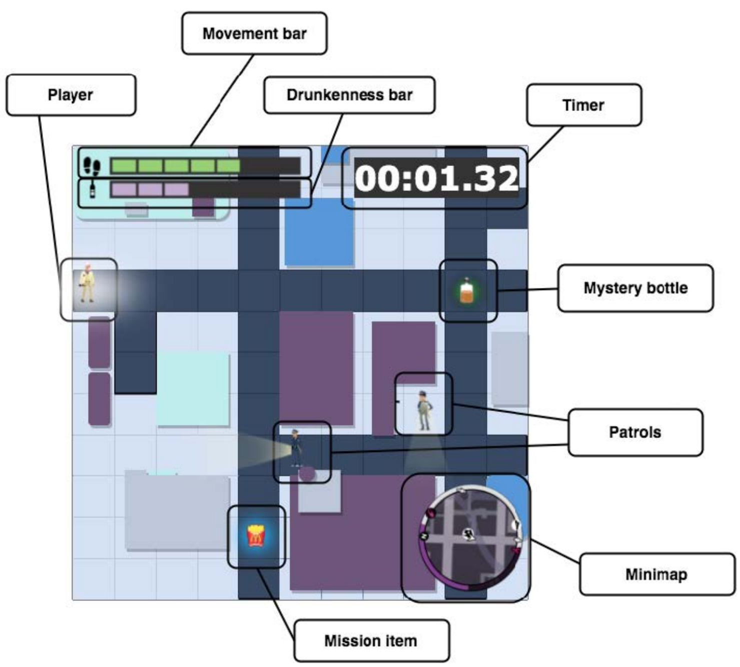

Fig. 2. Planning mock-up of Pubcrawler's UI

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As the game aims to simulate navigating a city while under alcohol-induced impairment, the movement and controls of the main character have been given a degree of unreliability and unpredictability. The player's movement is limited to four directions: up, down, left and right. For every movement the player attempts to make in quick succession, the chance of the player making a random movement instead increases. Short sessions of movement reduce the variability, but when the game requires sustained movement, the player will feel the effects of the impairment on his controls more acutely. This makes the player's journey home less straightforward and puts the player in a position where they do not feel completely in control, especially when obstacles or non-player characters (NPCs) must be avoided. The player may encounter 'mystery bottles' which are items scattered around the map that the player can choose to immediately use. These appear to be normal 'game collectibles' (to motivate the player to use them) and the player is not explicitly told what effect these may have. The very first mystery bottle the player comes across provides a positive effect, i.e. it reduces the chance of a random movement. However, the player eventually discovers that every mystery bottle thereafter has a random chance of either positively or negatively affecting the player. The appearance of the mystery bottle and the random effect combined serve as a representation of the alcoholic's compulsion to drink and the 'just one more drink' mentality. Because of the player's initial positive experience with the mystery bottle and their awareness of the chance of a positive effect from the mystery bottles, the player picks up more mystery bottles to push their luck.

Pubcrawler does not aim to be an explicitly educational game, but instead a casual game with hidden depth. The player may feel a growing unease as the game progresses and it becomes apparent that the main character is an alcoholic. This is intended to reflect how alcoholism often creeps up on both the alcoholic themselves and their loved ones. The game's narrative is presented mainly through texts sent between Clive and his roommate during drunk texting mini-games. The mini-game prompts are concerned texts sent by the roommate. As Clive, the player has the option to reply to their roommate's text in an attempt to assuage their worries and gain time (represented in-game as the player receiving a time bonus if they're successful). If the player accepts, they are shown a template message (Fig.3) reflecting common excuses that alcoholics may use when questioned about their drinking habits and/or statements that may reflect a problematic relationship with alcohol (Table 1). Currently, the message-response system works with the roommate's received text having a direct matching answer.

Clive's template responses are based on excuses outlined by the UK alcohol education charity Drinkaware, New Zealand's Health Promotion Agency, and results from a study on denial and rationalization in male alcoholics [9],[15],[7]. Because of the similar mentality, some common excuses for quitting smoking listed by the NHS have also been adapted for this [18]. Note that the lack of punctuation and capitalization in the responses is deliberate. From a gameplay perspective, this simplifies the mini-game mechanics, but thematically, this also

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Fig. 3. Pubcrawler's drunk texting mini-game

Table 1. Message-response between Clive and his roommate reflecting common excuses and rationalizations that may be used by an alcoholic

Text Received from Roommate	Clive's Response
You're going out drinking again?	only for a few drinks
Maybe don't go too hard tonight, yeah?	its fine i can stop when i want
I'm worried about how much you're drinking lately	i dont drink any more than my friends
You've been drinking quite a lot	i mean i drink lots sometimes but im not an alcoholic
Maybe it's time to stop, mate	its just not the right time
I'll be frank: I think you might have an alcohol problem	my life isnt ruined so i cant be an alcoholic

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makes the responses more similar in style to texts that a drunk person may send. In this way, the player is basically forced to respond in the way an alcoholic would, 'typing out' the template message letter-by-letter on an onscreen phone keyboard while under time pressure. The more 'coherent' the response (i.e. the more characters in the message that the player correctly types out before the mini-game timer runs out), the more extra time the player is given to complete the level. At the same time, the user must avoid encounters with the police where he will be deemed inebriated enough to be detained. As a game mechanic, this thematically augments the navigation impairment to add to the claustrophobia of play and completion.

3 Conclusions and Future Work

This paper has outlined the design of a simulation game for improving understanding and awareness of alcoholic behavior. At this stage, an early prototype of Pubcrawler has been developed with the core game mechanics in place and including a small sample level. The next step in development will involve the creation of multiple, larger levels as well as fleshing out the game narrative. Moving forward, this study will investigate the following research question: does the game more effectively promote awareness and empathy around alcoholic behavior in comparison with a more traditional training session? This would be measured by a series of questions that are given to two separate groups: one that has had the traditional presentation, and one that has had the presentation in combination with some time playing the game. Alternatively, two versions of the game could be tested against each other for motivation and empathy. Questionnaires will be administered to participants before and after the experiment. The pre-questionnaire will be used to gather demographic data and to determine baseline knowledge and empathic response. The post-questionnaire will be aimed at testing knowledge acquisition (e.g. recognition of signs of a potentially unhealthy relationship with alcohol) and whether particular emotional responses are induced in the player (e.g. frustration, loss of control, fear of being caught, etc). The resulting data could then be analyzed using an independent samples t-test to determine whether a significant difference in the reception between the traditional presentation and the game exists. UX testing will also be conducted for UI sentiment using an expanded version of the System Usability Scale (SUS) [6]. From there, we would expect to liaise with charities in order to test the application's effectiveness for treatment or reflection of behavior choices in alcoholics. At the least, it is expected to open up a discussion and raise awareness.

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